DUCKLING SURVIVAL AND INCUBATION BEHAVIORS IN COMMON GOLDENEYES IN INTERIOR ALASKA

By

Joshua Harold Schmidt

RECOMMENDED:

Abby N. Powell

Advisory Committee Chair

Edward C M

Chair, Department of Biology and Wildlife

APPROVED:

Dean, College of Science, Engineering, and Mathematics

Susan M Henrichs

Dean of the Graduate School

June 29, 2004

Date

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Joshua Harold Schmidt, B.S.

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ABSTRACT

The lack of research on the Common Goldeneye (*Bucephala clangula*) in Interior Alaska prompted this study. My objectives were to estimate duckling survival relative to several explanatory variables and to characterize incubation behaviors in a subset of females nesting in the Chena River State Recreation Area. My estimates of duckling survival were higher than previously reported for this species: 0.65 (95% CI 0.49 to 0.82) and 0.68 (95% CI 0.58 to 0.79) for 2002 and 2003 respectively. Seasonally, duckling survival increased linearly throughout 2002, remained nearly constant in 2003, and was negatively related to daily precipitation in both years. Nest attendance patterns and incubation behaviors were not related to weather, female experience, clutch size, or day of incubation. Average number of recesses per day (2.9 ± 0.05), length of recesses (100.7 ± 1.5 min), and incubation constancy (79.8 ± 0.3%) were similar to values previously reported for this species (mean ± SE). I observed nocturnal recesses in this population. Although not previously reported for this species, these recesses may occur due to extended daylight hours during the incubation period.

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INTRODUCTION

The common goldeneye (*Bucephala clangula*) breeds worldwide in northern boreal forests (Eadie et al. 1995) and will readily occupy nest-boxes, facilitating the study of its breeding biology. The population that we studied nested in a group of 150 nest-boxes located on the Chena River State Recreation Area in Interior Alaska during 2002 and 2003.

Common goldeneyes in Interior Alaska are at the northern limit of their range, which may entail certain constraints associated with the shortened breeding season at this latitude. Research on common goldeneyes in Alaska is generally lacking, and breeding pair surveys are the only published information for this species in the state (U.S. Fish and Wildlife Service 1999). The lack of general knowledge for this species in Alaska prompted this study to investigate duckling survival and incubation behaviors.

Basic information is needed for management of any species to be effective, and the survival of young is very important for the management of this species and waterfowl in general. Low duckling survival until fledging could limit recruitment into the breeding population and population growth. With no estimates of duckling survival for common goldeneyes in Alaska, I believed that this would be an appropriate aspect of breeding biology to investigate. Estimates of duckling survival could begin to provide some insight into the status of common goldeneye populations in Alaska.

I estimated duckling survival from the day of hatch until 30 days of age through the use of radio-transmitters attached to brood-rearing females and color marks applied to individual ducklings. Females were relocated periodically to obtain complete counts of ducklings remaining in each brood. I then fit models to the data to help explain variation in duckling survival rates.

In the process of collecting duckling survival information, I concurrently collected brood-movement data (Appendix A). Invertebrates were collected at both nest and brood-rearing locations for a subset of the monitored broods when ducklings reached two weeks of age (Appendix A).

Incubation behavior could also be an important component of the breeding biology of this species due to the energetic demands on incubating females (Afton and Paulus 1992). I believed that nesting conditions may be more extreme on our study area than at more southern latitudes, with egg-laying beginning when evening temperatures may dip below 0°C and daytime highs during incubation reaching as high as 30°C. Decreased levels of nest attendance could result in lowered nest success or higher predation rates (Afton and Paulus 1992). Day-length and the range of daily temperatures were greater on my study site; therefore, I expected incubation behaviors to be different than more southern populations. Also, insight into incubation behaviors and variables that influence them may help managers with nest-box placement or design.

I investigated nest attendance patterns and incubation behaviors during the nesting period by monitoring nest temperatures with temperature sensing dataloggers. Nine of the dataloggers provided information during the egg-laying period (Appendix B). Three incubation components: constancy, number of recesses, and duration of recesses were analyzed in relation to environmental and female specific variables to identify factors that may influence incubation behavior.

The first chapter of the thesis describes common goldeneye duckling survival relative to environmental variables and female characteristics and is formatted for submission to the Journal of Wildlife Management. The second chapter relates incubation behavior to environmental and female specific variables and is formatted for submission to the Condor.

Chapter 1.

SURVIVAL OF COMMON GOLDENEYE DUCKLINGS IN INTERIOR ALASKA[1]

Abstract: Baseline estimates of duckling survival are necessary to examine population dynamics in common goldeneyes (*Bucephala clangula*), and ours is the first study to estimate duckling survival in relation to several relevant covariates in Interior Alaska. We color-marked common goldeneye ducklings from 91 broods and radio-marked 39 females from a nest-box population in the boreal forest during the summers of 2002 and 2003. We monitored 46 broods in 2002 and 2003 combined and estimated daily survival rates (DSR) and survival to 30 days of age using program MARK. We modeled DSR in relation to year, linear trend across season, duckling age, female age, female body condition, initial brood size, and daily precipitation. Duckling survival estimates to 30 days of age from the average hatch date were 0.65 (95% CI 0.49 to 0.82) and 0.68 (95% CI 0.58 to 0.79) for 2002 and 2003 respectively. Our best approximating model indicated that survival differed by year and increased in a linear manner over the course of the 2002 season. Precipitation had a consistent negative effect on duckling survival in both years, while duckling age did not influence survival rates. We caution that in light of the general decline of many Alaskan populations of sea ducks, more effort should be expended on common goldeneye population estimates and monitoring.

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[1] Prepared for submission to Journal of Wildlife Management as Schmidt, J. H., E. J. Taylor, and E. A. Rexstad. Survival of common goldeneye ducklings in Interior Alaska.

INTRODUCTION

Population studies for most Alaskan sea ducks are few (but see Flint and Grand 1997, Esler et al. 2000, Flint et al. 2000), and research on common goldeneyes in Alaska is quite limited. Data from the North American Waterfowl Breeding Population Survey indicate that common goldeneye populations across North America are probably stable (USFWS 1999), but to our knowledge no other information is available for this species in Interior Alaska. The most recent information indicates that Steller's eiders (*Polysticta stelleri)*, spectacled eiders (*Somateria fischeri*), and long-tailed ducks (*Clangula hyemalis*) have experienced long-term declines, and scoters (*Melanitta* spp.), harlequin ducks (*Histrionicus histrionicus*), and scaup (*Aythya* spp.) all deserve special attention (USFWS 1999). Long-term declines in these species of sea ducks along with the general lack of research on common goldeneyes in Alaska make further study imperative.

The number of ducklings surviving until fledging is an important component of the study of population dynamics in waterfowl (Johnson et al. 1992). Although common goldeneye females can breed for many years (Ludwichowski 2002), lifetime reproductive output per female is typically low (Eadie et al. 1995). This makes the understanding of duckling survival and the factors that may influence it even more important.

Our objectives were to determine daily survival rates of ducklings from hatching to 30 days of age, and identify variables that affect duckling survival.

Factors affecting duckling survival during the first month after hatch may help managers concentrate effort on segments of the breeding population that fledge the most young, such as older or early nesting females. Estimates of the relative effects of various environmental conditions may also allow managers to estimate the success of broods based on environmental conditions during the peak of the brood-rearing period.

STUDY AREA

We conducted our study in central Alaska on the Chena River State Recreation Area during the summers of 2002-2003. The study area encompassed approximately 102 km^2 along the north and middle forks of the Chena River. Nest-boxes (n=150) were located on sloughs, oxbows, ponds, and along the Chena River at heights of 3-7 m above the ground. These boxes have been monitored and maintained since 1997 during which time the numbers of nesting females have steadily increased. The sites were dominated by mixed stands of white spruce (*Picea glauca*), paper birch (*Betula papyrifera*), black spruce (*Picea mariana*), and balsam poplar (*Populus balsamifera*). Weather data were acquired from the Two Rivers National Weather Service weather station (64° 53' 55"N latitude, 146° 24' 42"W longitude), located within our study area.

METHODS

Nesting

We inspected nest-boxes weekly beginning in May to determine occupancy. We revisited active nests every 1 to 3 days to determine egg-laying rates and to capture adult females on the nest. Revisits occurred until we captured the adult female or the clutch neared completion. We eliminated subsequent visits until late incubation to reduce the possibility of nest abandonment (Eadie et al. 1995). We assumed abandonment was caused by research activities when embryo development was unchanged between nest visits after disturbing the female.

We revisited nests during late incubation and all eggs were candled to determine their stage of incubation (Weller 1956) and anticipated hatch date assuming an incubation period of 28 days (Bellrose 1980). We measured egg length and width to the nearest 0.1 mm using dial calipers, and mass to the nearest 0.5 g with a Pesola scale for each new egg on each visit. We used a permanent marker to number the eggs to identify new or missing eggs.

Females were captured on their nests by blocking the nest-box entrance with a conical piece of foam affixed to the end of a telescoping pole. Measurements of culmen length, head length, tarsus length, and body mass were recorded for all nesting females on initial capture, and a USFWS metal leg band was affixed to the right leg if the bird was unbanded. Approximately ninety percent of breeding females had been previously marked with leg bands either as breeding adults or as day-old ducklings (E. Taylor, unpub. data), and in those cases the band number was recorded. We recorded body mass to the nearest 5 g and verified the band number on all subsequent recaptures.

At hatch, we marked all ducklings from most broods with plasticine-filled metal leg bands (see Blums et al. 1994). We also weighed ducklings to the nearest 0.5 g, and colored their white cheek patches using permanent markers (Eadie 1989). Each brood received a unique color combination so that broods could be identified in case of radio loss or brood amalgamation. The marks remained visible for 4-5 weeks and allowed opportunistic observations of broods without a radioed female present and aided brood identification from a distance. Radio and color monitored broods were sampled from the range of hatch dates each season and were from nests throughout the study site. The females monitored using these 2 methods were from all age classes present in the breeding population from first time breeders, 2 years of age (based on plasticine leg-bands) to females at least 8 years of age.

Telemetry

At hatch, in 2002 and 2003 we attached radio-transmitters to 19 and 20 adult females respectively. In 2002, a 13 g tail-mounted VHF radio (model G3, AVM Instrument Company, Ltd., Colfax, California, USA), similar to the model used by Poysa and Virtanen (1994), was affixed to the central 2 retrices. In 2003, we used a modified prong and suture mount similar to that developed by Mauser and Jarvis (1991) to affix a 9 g VHF radio-transmitter (model A4430, Advanced Telemetry Systems, Inc., Isanti, MN, USA) between the scapulars of the female. After radio attachment, we either released the female to the water or placed her back in the nest with the ducklings depending on the ambient temperature and the apparent stress level of the bird. We included only females known to have bred at least once previously in the transmittered group to avoid potential researcher caused abandonment due to the extra handling time necessary for radio attachment. All procedures were approved by the Institutional Animal Care and Use Committee at the University of Alaska Fairbanks (IACUC #02-20).

We relocated broods with a hand-held Yagi antenna every 3-5 days if possible and visually confirmed the identity of the brood based on the presence of the radioed hen and the color marks on the ducklings. We counted the number of ducklings and recorded the location of the brood with a handheld GPS unit. We assumed that ducklings not observed on subsequent visits had died during the previous interval. Ducklings were usually gathered around the female enabling accurate counting, and absent ducklings were not present during subsequent visits. We had no way of verifying the death of the ducklings, so our survival estimates could be biased low if ducklings left broods undetected but remained alive.

When possible, we relocated broods until they reached at least 30 days of age. We assumed complete brood loss when the female was observed without her brood on 2 or more separate days and did not display normal brood protection behavior. Normal behavior of females with broods included calling, and attempting to swim away from the observer rather than flying. Once per season, we used a fixed-wing aircraft to aid in the relocation of broods that had moved out of range of the hand-held antenna. After plotting the general location of a brood from the air, we acquired a visual relocation and duckling count from the ground within 3 days if possible.

Invertebrate Sampling

For a subset of the monitored broods, we collected aquatic invertebrates in both nest and brood-rearing locations when the ducklings reached 2 weeks of age for an index of food availability and richness. We used activity traps (see Murkin et al. 1983) to randomly sample invertebrates by placing 5 traps throughout the wetland where the brood hatched, and 5 traps thoughout the brood location when ducklings were 2 weeks of age. Traps were retrieved after 48 hours, contents were sieved through a 1mm mesh, and the remaining invertebrates were identified to family, counted, and measured to the nearest millimeter.

Survival Estimation

We determined survival in a similar manner as Ringelman and Longcore (1982) and Savard et al. (1991) by observing marked females and broods to determine daily survival rates. We estimated duckling survival from hatching until 30 days of age by modeling daily survival rate (DSR) using the nest survival module in program MARK (White and Burnham 1999). We considered year, date, initial brood size, female age, female body condition (body mass relative to structural size), duckling age, and daily precipitation as potential explanatory variables, and ranked models using Akaike's Information Criterion (AIC). We then used AIC_c weights to select the best approximating model (Anderson et al. 2000).

Year was included to identify differences between years to account for unmeasured factors that possibly differed between years, such as predation levels. We hypothesized that the brood size at hatch may affect duckling survival (Guyn and Clark 1999). Increased brood-size may increase survival due to better predator detection by the group as a whole, or brood size may negatively affect survival by decreasing the ability of the female to efficiently brood young ducklings during inclement weather (Dzus and Clark 1997).

We also included female age as a possible factor contributing to differences in duckling survival caused by varying levels of brood-rearing experience. Our sample contained birds of all ages from 2 years to at least 8 years of age, and we hypothesized that older more experienced females may be better able to care for young or better able to secure higher quality habitats for their broods.

We also used the relationship between female structural size and body mass at hatch as an indicator of body condition. We hypothesized that body condition may be an important factor in a female's ability to care for her young because females in poor condition may need to spend more time feeding, leaving less time to care for and protect their young. Other waterfowl research has found a positive relationship between body condition and brood survival (Yerkes 2000, Gendron and Clark 2002). We used a procedure similar to that used by Gendron and Clark (2002) to obtain an index of female body condition at the time of hatch. Using SAS V.8 we conducted a principle components analysis, using culmen length, head length, and tarsus length to calculate an index of female structural size (PC I PROC PRINCOMP; SAS Institute 1999). We then conducted a linear regression (PROC REG; SAS Institute 1999) between body mass and PC I scores and used the resulting residuals as indices of body condition (Gendron and Clark 2002).

We also considered the effect of duckling age and daily precipitation on survival. It is common for duckling mortality to be higher in the first 1-2 weeks after hatch and then decline as ducklings age (Savard et al. 1991, Grand and Flint 1996, Flint and Grand 1997, Guyn and Clark 1999). Daily precipitation was recorded at the Two Rivers National Weather Service weather station (64° 53' 55"N latitude, 146° 24' 42"W longitude) located within the study area. Increased amounts of daily precipitation were predicted to decrease duckling survival due to increased thermoregulatory costs (Dzus and Clark 1997) or decreased foraging efficiency (Sjoberg and Danell 1982).

We used program MARK to model duckling DSR in part due to unequal resighting intervals. Known fate models are often used for this type of analysis, but require the resighting intervals to be equal. Using the nest survival module may violate the assumption of independence between sampling units due to dependence among brood mates, but it allowed us to address DSR using individual ducklings as the sampling unit. This module also allows the use of covariates and follows the same format used by Dinsmore et al. (2002) for nest survival data. We standardized the first hatch date (June 3 in this case) as day 1 and numbered all relocation dates sequentially thereafter (Dinsmore et al. 2002). By treating our duckling data as sampling units, the first age was always 1 because all ducklings were "found" on the day of hatch. We numbered the remaining days sequentially thereafter until reaching the end of the observation period. We coded our encounter histories in the same manner as Dinsmore et al. (2002).

Our candidate model set included the simplest possible model where the daily survival rate was constant within season and between years. We then let survival vary by year and included a linear time trend with the assumption that DSR may change linearly throughout the brood-rearing period. We also added the variables initial brood size, female age, female body condition at hatch, duckling age, and amount of daily precipitation singly and in combination to find the model that explained the most variation in the data. After fitting all of our potential models, we then adjusted the output for over-dispersion before selecting the best model. An analysis of only the 2003 data was conducted to investigate the potential for a marker effect both alone and with the other covariates.

RESULTS

We marked 283 ducklings from 44 broods in 2002, and 360 ducklings from 47 broods in 2003. Of these we monitored 15 and 31 broods in 2002 and 2003, respectively. In these monitored groups we included broods that did not receive radios, but were identified by color-code identification alone (4 of 15 in 2002, 14 of 31 in 2003), allowing us to record duckling survival information for 18 more broods than would have been possible using radios only. Brood amalgamations were rarely observed in this study (1 brood gained ducklings). Female nest abandonment rates during 2002 and 2003 that could potentially be attributed to research activities were low, with 4 and 1 abandonments in each year respectively.

Invertebrate samples were collected for 14 and 17 broods in 2002 and 2003, respectively (Appendix A). In 2002 for each wetland, the mean number of families was 9.1 (SE = 2.7) for nesting areas and 8.4 (SE = 2.0) at brood-rearing locations. The mean number of invertebrates was 145 (SE =197) in nesting areas and 121 (SE = 104) at brood-rearing locations. In 2003 for each wetland, the mean number of families was 7.9 (SE = 2.5) in nesting areas and 10.5 (SE = 2.9) at brood-rearing locations. The mean number of invertebrates was 162 (SE = 194) in nesting areas and 232 (SE = 212) at brood-rearing locations. A z-test indicated that the number of families was higher in brood-rearing areas than in nesting areas in 2003 ($P = 0.002$), but no other comparisons of means between nesting and brood-rearing areas within years indicated any differences.

After fitting all the models in our candidate set, we adjusted for a $\hat{c}$ value of 1.8 to account for over-dispersion in the data due to lack of independence of brood mates. To estimate $\hat{c}$, we used the deviance divided by the deviance degrees of freedom. This is a conservative method, but there is currently no other way to estimate the degree of over-dispersion in the nest survival module (Dinsmore et al. 2002). We felt that using this conservative estimate was justified to prevent the selection of a more highly parameterized model than our data could actually support. After this adjustment, we had a high degree of uncertainty in our model selection, with the top 5 models all within 1 $\Delta QAIC_c$ unit of one another (Table 1).

We present the results from the top model $S_{year*T+precip}$ although many models have nearly equal support (Table 1). There was a significant effect of year (β_{year} = -2.07, SE = 0.82, 95% CI -3.68 to -0.45) on a logit scale. The best approximating model also included a weak linear trend with date which was only significant in 2002 ($\beta_{T\ 2002}$ = 0.09, SE = 0.04, 95% CI 0.01 to 0.17 and $\beta_{T\ 2003}$ = 0.0042, SE = 0.02, 95% CI -0.04 to 0.05) on a logit scale. The interaction between year and date appeared in all 6 of the top models. Daily precipitation had a negative effect on DSR in both years (β_{precip} = -2.68, SE = 1.10, 95% CI -4.83 to -0.53) on a logit scale. In 2002, a majority of the precipitation events occurred in the first half of the brood-rearing season, while in 2003 a majority of the precipitation events occurred in the latter half of the season (Fig. 1).

There was an apparent weak positive effect of initial brood size on DSR in the second best model ($\beta_{broodsize}$ = 0.22, SE = 0.16) on a logit scale, but the confidence intervals around the parameter estimates included 0 (95% CI -0.10 to 0.54). This was the case for all models containing initial brood size. The confidence limits for the variables female age, female body condition, and brood age also included 0 in all models and are not considered further. This was also the case in the analysis of marker effect for the 2003 data. In all models including a variable for marker effect (radio vs. color-marked only), the confidence limits for that variable included 0.

We used our top model to estimate the survival rate to 30 days of age for ducklings that hatched on the mean yearly hatch date. Our estimates were 0.65 (95% CI 0.49 to 0.82) and 0.68 (95% CI 0.58 to 0.79) for 2002 and 2003 respectively. We used the delta method (Seber 1982) to calculate the variance and estimate the precision of all 30 day survival estimates.

DISCUSSION

Duckling Survival

No published estimates of common goldeneye duckling survival exist for Interior Alaska, and our estimates are higher than those calculated for other populations. In British Columbia, survival to near fledging averaged 0.37 (Eadie et al. 1995), and in Ontario survival rates to near fledging ranged from 0.31-0.53 (Wayland and McNicol 1994). We did not observe the pattern of high mortality early in brood rearing reported in Barrow's goldeneyes (Savard et al. 1991), northern pintails (Grand and Flint 1996, Guyn and Clark 1999), and spectacled eiders (Flint and Grand 1997). Models containing brood age were not included in the top model set, and the confidence intervals for this variable always included 0. There was a slight increase in DSR through the brood rearing period in 2002, but this may have been caused by fewer precipitation events during the latter part of the season (Fig. 1). In 2003, duckling survival appeared to be nearly constant except for decreases in DSR on days with precipitation. The conclusion that precipitation negatively affects duckling survival is supported by studies of Laysan ducks (*Anas laysanensis*) (Moulton and Weller 1984) and Barrow's goldeneyes and buffleheads (*Bucephala albeola*) (Savard et al. 1991).

We found some support for models including initial brood size as a covariate, but the confidence intervals around the parameter estimate included 0 in all models. Dzus and Clark (1997) found that in artificially enlarged broods, variation in the temperature experienced by ducklings during brooding was higher than in smaller broods, which could decrease survival during inclement weather. Female body condition and female age also appeared in the model set although the corresponding confidence intervals included 0 as well. No effect of female age was found in a population of redheads (*Aythya americana*) in Manitoba (Yerkes 2000), but there is some evidence suggesting that broods of older females and females in better condition may have higher survival (Johnson et al. 1992). Our sample size may not have been sufficient to detect any effect of female age or body condition, therefore, future studies should consider them as potential factors that may influence duckling survival.

The pooling of radio-marked females with broods and color-marked broods in the analysis may cause some speculation that our estimates were biased due to unequal detection probabilities. We do not believe this was the case with our sample because our point estimates of survival to 30 days were very similar between years despite the difference between years in the proportion with radios. Also, an analysis of the 2003 data in relation to marker type did not support differences in survival rates based on the type of marker used for relocation. It could also be argued that we would not detect total brood loss without radioed females present, but within our radioed sample (n=39), we observed total brood loss in only 2 cases. This suggests that total brood loss was uncommon in our population.

Our estimates of survival to 30 days are higher than reported for other species of sea ducks, such as spectacled eiders (0.34) (Flint and Grand 1997) and common eiders (*Somateria mollissima*) (0.10) (Mendenhall and Milne 1985). This difference could be due in part to habitat and predator differences of these areas. Tundra nesting species like eiders are likely exposed to higher levels of predation due to the exposed nature of the nesting habitat. Ducklings have little escape cover in tundra habitats and could be easier prey than ducklings raised in boreal forest habitats. Few estimates of duckling survival are available for the boreal forest (but see Walker 2004), and further research is needed in these areas.

Ducklings of cavity nesters appear to have higher survival rates to near fledging than ducklings of some ground nesting species. Savard (1986) found that survival of bufflehead ducklings was approximately 0.64, and a review of several wood duck studies indicated that estimated survival rates of ducklings ranged from 0.35 to 0.59 (Sargeant and Raveling 1992). This may indicate that cavity nesters invest more in each nesting attempt than other species of waterfowl. Nest success on our study area was quite high (approximately 0.80), and combined with high duckling survival, a large proportion of the young likely contributed to the fall migrating population.

High duckling survival to 30 days could have been the result of certain habitat features within the study site, such as an abundance of potential brood-rearing wetlands. Wayland and McNicol (1994) found that common goldeneye duckling survival was higher on clustered wetlands than on isolated wetlands. Abundant and complex wetlands on our study site formed by old river channels and beaver (*Castor canadensis*) activity, as opposed to large lakes (see Eadie 1989), may have reduced brood interactions and infanticide by common goldeneye females (see Savard 1987), while providing abundant areas of accessible invertebrate foods. Savard (1987) suggested that brood mixing is largely caused by territorial disputes in Barrow's goldeneyes (*Bucephala islandica*). The lack of brood amalgamation in this study may indicate that such interactions were uncommon. Nest boxes were located in only a small portion of the habitat available to common goldeneye broods due to the limits of accessibility, and many females (n≥11) led their ducklings long distances (2-11km) from the nest site to brood-rearing areas, which may have reduced territorial conflicts (Appendix A). The proximity of the Chena River, generally less than 0.5km from nest sites, facilitated these long distance brood movements without requiring overland travel. Broods were often observed on the river during radio-relocations and likely used the river to move between wetlands.

High survival could also be related to factors such as predator abundance that we did not measure, or food availability which we were unable to adequately quantify. Predators have been identified as important sources of duckling mortality in other species of waterfowl (Talent et al. 1982, Mauser et al. 1994, Grand and Flint 1996). Other studies have indicated that common goldeneye females select habitats with more abundant invertebrate populations (Poysa and Virtanen 1994) and that brood survival is higher in these habitats (Eriksson 1978, Wayland and McNicol 1994). Our measures of invertebrates in brood-rearing and nesting areas were highly variable, which prevented us from identifying differences between the two habitats in either the number or richness of potential food resources. The only difference we detected indicated that richness in 2003 was greater in brood-rearing areas than in nesting areas. Often broods only remained at the sampling location for 1 day, while others remained on a particular wetland for weeks. This variability in rate of use prevents definitive conclusions from being drawn.

Duckling survival to near fledging does not appear to be limiting in this population. Our survival estimates are higher than those reported in other populations of common goldeneyes and other species of waterfowl, and nest-box occupancy has steadily increased since intensive monitoring began in 1997 (Taylor unpbl.). Mortality during other portions of the life cycle may play a larger role in determining the number of females that return to the study site to breed in subsequent years.

Management Implications

The number of breeding females using nest boxes has increased yearly from 1997-2003 in our study area (E. Taylor unpub. data), indicating that the local population may be increasing. Currently the North American population of common goldeneye is thought to be stable (USFWS1999); however, monitoring of the breeding population should be improved to provide more accurate population estimates so that changes in abundance can be readily identified. USFWS breeding pair surveys do not adequately estimate common goldeneye abundance due to the timing and coverage of surveys (USFWS 1999).

Future studies should attempt to quantify predation, food availability, and the spatial characteristics of the available habitat, and their potential relationships to duckling survival in this species. We did not adequately quantify these variables, but they could play an important role in determining duckling survival. These may be responsible for some of the differences between years, and identifying them could prove useful in future management decisions concerning wetland preservation and recreational uses of brood-rearing areas. If food availability is important and can be adequately quantified, managers could identify potentially important wetlands for brood-rearing and exclude them from development plans. Activity traps were effective for invertebrate collection, but more frequent samples of larger numbers of broods would be necessary to detect differences that contribute to variability in DSR's between habitats.

Further research should also be conducted to investigate potentially limiting factors such as over-winter survival, contaminants, and the availability of suitable nest sites. In other portions of their range, particularly the Great Lakes region, goldeneyes experience elevated contaminant loads (Smith et al. 1985, Foley and Batcheller 1988), but little is known about contaminants in Alaskan populations. The USFWS (1999) also suggested that logging of old growth forests in southeast and south-central Alaska may reduce the availability of nest sites, so nest-boxes may prove useful in the future if Alaskan population declines are detected.

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LITERATURE CITED

Anderson, D. R., K. P. Burnham, and W. L. Thompson. 2000. Null hypothesis testing: problems, prevalence, and an alternative. Journal of Wildlife Management 64:912-923.

Bellrose, F. C. 1980. Ducks, geese, and swans of North America. Stackpole Books, Harrisburg, Pennsylvania, USA. 540p.

Blums, P., A. Mednis, and J. D. Nichols. 1994. Retention of web tags and plasticine-filled leg bands applies to day-old ducklings. Journal of Wildlife Management 58:76-81.

Dennis, R.H., and H. Dow. 1984. The establishment of a population of goldeneyes *Bucephala clangula* breeding in Scotland. Bird Study 31: 217-222.

Dinsmore, S. J., G. C. White, and F. L. Knopf. 2002. Advanced techniques for modeling avian nest survival. Ecology 83:3476-3488.

Dzus, E. H., and R. G. Clark. 1997. Brood size manipulation in mallard ducks: effects on duckling survival and brooding efficiency. Ecoscience 4:437-445.

Eadie, J. M. 1989. Alternative reproductive tactics in a precocial bird: the ecology and evolution of brood parasitism in goldeneyes. Dissertation. University of British Columbia, Vancouver, Canada.

Eadie, J., M. Mallory, and H. Lumsden. 1995. Common Goldeneye (*Bucephala clangula*). *In* The Birds of North America, No. 170 (A. Poole and F. Gill, eds.) The Academy of Natural Sciences, Philadelphia, and the American Ornithologists' Union, Washington, D.C.

Eriksson, M. O. G. 1978. Lake selection by goldeneye ducklings in relation to the abundance of food. Wildfowl 29:81-85.

Eriksson, M. O. G. 1979. Aspects of the breeding biology of the goldeneye *Bucephala* clangula. Holarctic Ecology 2:186-194.

Esler, D., T. D. Bowman, C. E. O'Clair, T. A. Dean, and L. L. McDonald. 2000. Densities of Barrow's Goldeneyes during winter in Prince Williams Sound, Alaska in relation to habitat, food, and history of oil contamination. Waterbirds 23:423-429.

Flint, P. L., and J. B. Grand. 1997. Survival of spectacled eider adult females and ducklings during brood rearing. Journal of Wildlife Management 61:217-221.

Foley, R. E., and G. R. Batcheller. 1988. Organochlorine contaminants in Common Goldeneye wintering on the Niagara River. Journal of Wildlife Management 52:441-445.

Gendron, M., and R. G. Clark. 2002. Survival of gadwall and mallard ducklings in southcentral Saskatchewan. Journal of Wildlife Management 66:170-180.

Grand, J. B., and P. L. Flint. 1996. Survival of northern pintail ducklings on the Yukon-Kuskokwim Delta, Alaska. Condor 98:48-53.

Guyn, K. L., and R. G. Clark. 1999. Factors affecting survival of northern pintail ducklings in Alberta. Condor 101:369-377.

Johnson, D. H., J. D. Nichols, and M. D. Schwartz. 1992. Population dynamics of breeding waterfowl. Pages 446-458 *in* B. D. J. Batt, A. D. Afton, M. G. Anderson, C. D. Ankney, D. H. Johnson, J. A. Kadlec, and G. L. Krapu, eds. Ecology and management of breeding waterfowl. University of Minnesota Press, Minneapolis.

Ludwichowski, I., R. Barker, and S. Brager. 2002. Nesting area fidelity and survival of female common goldeneyes *Bucephala clangula*: are they density-dependent? Ibis 144:452-460.

Mauser, D. M., and R. L. Jarvis. 1991. Attaching radio transmitters to 1-day-old mallard ducklings. Journal of Wildlife Management 55:488-491.

Mauser, D. M., R. L. Jarvis, and D. S. Gilmer. Survival of radio-marked mallard ducklings in northeastern California. Journal of Wildlife Management 58:82-87.

Mendenhall, V. M., and H. Milne. 1985. Factors effecting duckling survival of eiders *Somateria mollissima* in northeast Scotland. Ibis 127:148-158.

Moulton, D. W., and M. W. Weller. 1984. Biology and conservation of the Laysan duck (*Anas laysanensis*). Condor 86:105-117.

Murkin, H. R., P. G. Abbott, and J. A. Kadlec. 1983. A comparison of activity traps and sweep nets for sampling nektonic invertebrates in wetlands. Freshwater Invertebrate Biology 2:99-106.

Poysa, H. 1999. Conspecific nest parasitism is associated with inequality in nest predation risk in the common goldeneye (*Bucephala clangula*). Behavioral Ecology 10:533-540.

Poysa, H., and J. Virtanen. 1994. Habitat selection and survival of common goldeneye (*Bucephala clangula*) broods-preliminary results. Hydrobiologia 279/280:289-296.

Ringleman, J. K., and J. R. Longcore. 1982. Survival of juvenile black ducks during brood rearing. Journal of Wildlife Management 46:622-628.

Sargeant, A. B. and D. G. Raveling. 1992. Mortality during the breeding season, p. 396-422. *In* B. D. J. Batt, A. D. Afton, M. G. Anderson, C. D. Ankney, D. H. Johnson, J. A. Kadlec, and G. L. Krapu [eds.], The ecology and management of breeding waterfowl. Univ. Minnesota Press, St. Paul, MN.

Savard, J. P. L. 1986. Territorial behaviour, nesting success and brood survival in Barrow's goldeneye and its congeners. PhD. Dissertation, University of British Columbia, Canada.

Savard, J. P. L. 1987. Causes and functions of brood amalgamation in Barrow's goldeneye and bufflehead. Canadian Journal of Zoology 65:1548-1553.

Savard, J. P. L., G. E. J. Smith, and J. N. M. Smith. 1991. Duckling mortality in Barrow's goldeneye and bufflehead broods. Auk 108:568-577.

Seber, G. A. F. 1982. The estimation of animal abundance and related parameters. Second edition. Macmillan, New York, New York, USA.

Sjoberg, K., and K. Danell. 1982. Feeding activity of ducks in relation to diel emergence of chironomids. Canadian Journal of Zoology 60:1383-1387.

Smith, V. E., J. M. Spurr, J. C. Filkins, and J. J. Jones. 1985. Organochlorine contaminants of wintering ducks foraging on Detroit River sediments. Journal of Great Lakes Research 11:231-246.

Talent, L. G., R. L. Jarvis, and G. L. Krapu. 1983. Survival of mallard broods in south-central North Dakota. Condor 85:74-78.

U.S. Fish and Wildlife Service. 1999. Population status and trends of sea ducks in Alaska. U.S. Fish and Wildlife Service, unpublished report. Migratory Bird Management, Anchorage, Alaska 99503.

Walker, J. 2004. Nest and duckling survival of scaup at Minto Flats, Alaska. M.S. Thesis. University of Alaska, Fairbanks.

Wayland, M., and D. McNicol. 1994. Movements and survival of Common Goldeneye broods near Sudbury, Ontario, Canada. Canadian Journal of Zoology 72: 1252-1259.

Weller, M. W. 1956. A simple field candler for waterfowl eggs. Journal of Wildlife Management 20:111-113.

White, G. C., and K. P. Burnham. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46:120-138.

Yerkes, T. 2000. Influence of female age and body mass on brood and duckling survival, number of surviving ducklings, and brood movements in redheads. Condor 102:926-929.

FIGURE 1. Estimates of common goldeneye duckling daily survival rates (DSR) (±95% CI) for 2002 (A) and 2003 (B) for each day of the season at Chena River State Recreation Area, Alaska. Dark circles on the x-axis under the downward spikes indicate days with measurable precipitation.

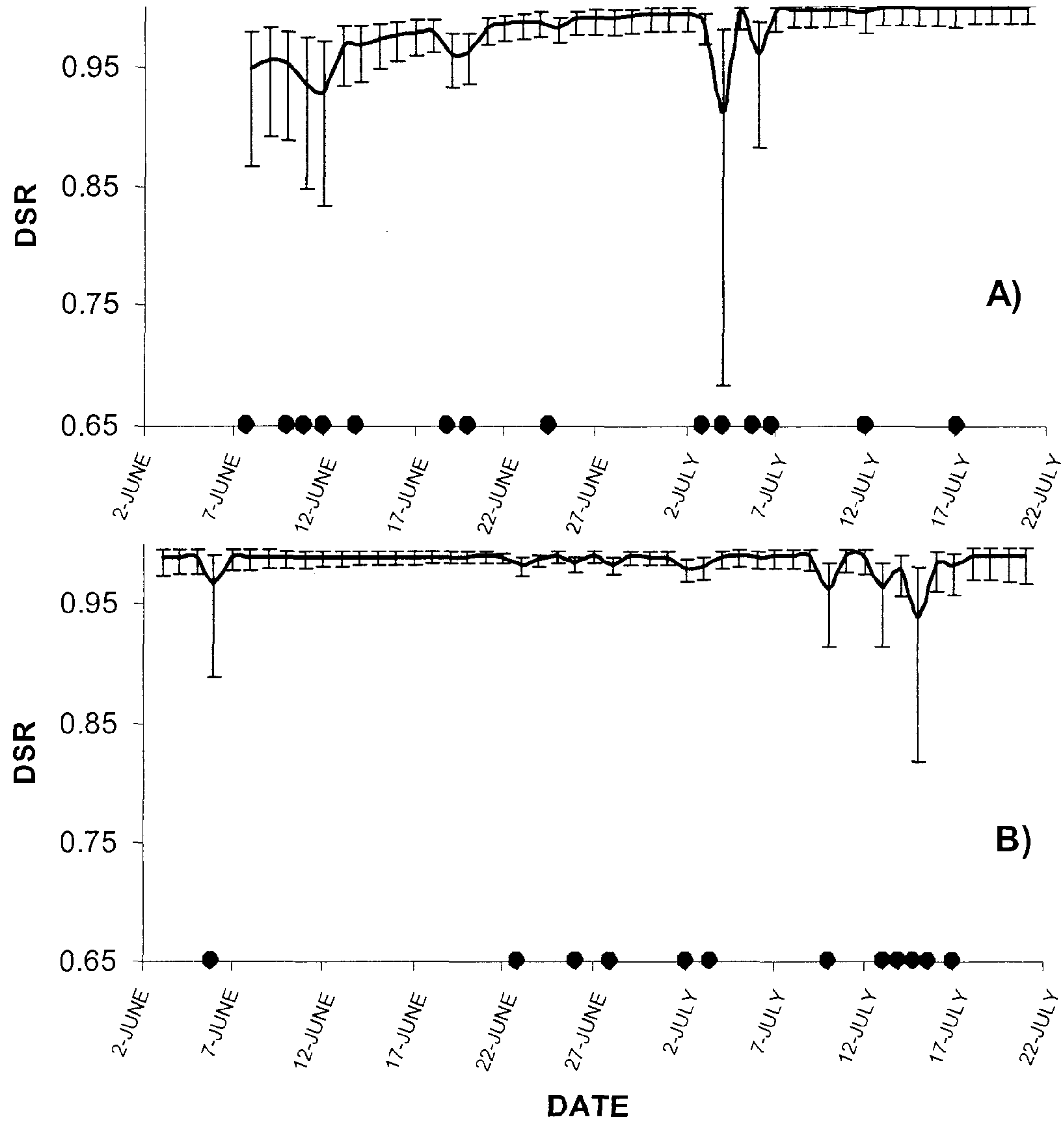

Table 1. Model selection results based on $\Delta QAIC_c$ values for common goldeneye duckling survival in the Chena River State Recreation Area, Alaska, 2002-2003 after adjusting for over dispersion ($\hat{c} = 1.8$).

Model[a]	$QAIC_c$	$\Delta QAIC_c$	No. of Parameters	Weight
$S_{year*T+precip}$	351.14	0.00	5	0.095
$S_{year*T+broodsize+precip}$	351.29	0.15	6	0.088
$S_{year*T+broodsize+hencond+precip}$	351.98	0.84	7	0.062
$S_{year*T+broodsize+hen\ age+precip}$	352.00	0.86	7	0.062
$S_{year*T+broodsize}$	352.11	0.97	5	0.058
S_{year*T}	352.18	1.04	4	0.056
S(•)	352.92	1.78	1	0.038
S_{year+T}	355.36	4.22	3	0.011

[a] Models are ordered by increasing $\Delta QAIC_c$. Model variables include year, date (T), daily precipitation (precip), initial brood size (broodsize), hen body condition (hencond), hen age, and constant daily survival (•).

Chapter 2.

INCUBATION BEHAVIORS AND PATTERNS OF NEST ATTENDANCE IN COMMON GOLDENEYES IN INTERIOR ALASKA[2]

Abstract. We hypothesized that nest attendance characteristics in Common Goldeneyes (*Bucephala clangula*) at the northern limit of their range differ from those of more southern populations. In 2002 and 2003, we used artificial eggs containing temperature sensing dataloggers to obtain nest attendance data from 20 incubating females over 515 days. We investigated recess behaviors in relation to daily temperature, precipitation, female experience, clutch size, and day of incubation. On average, each female spent 79.8 ± 0.3% of the day on the nest, and took 2.9 ± 0.1 recesses per day, each averaging 100.7 ± 1.5 minutes (mean ± SE). These recess characteristics were comparable to those reported for other Common Goldeneye populations. Most recesses (88%) occurred between 09:00 and 22:00 ADT although recesses were initiated at all times of day. The variability of recess times within the day was greater than at lower latitudes. We found no relationship between the average timing of recesses and maximum daily temperature, daily precipitation, female breeding experience, or incubation stage, although the variation among females was high. Female incubation behavior does not appear to be strongly influenced by the coarse-level environmental and female specific variables that we

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measured, but could be related to a complex assortment of fine-scale environmental or endogenous factors.

INTRODUCTION

Nest attendance and incubation patterns have been studied in many species of waterfowl (Afton and Paulus 1992), but incubation patterns of subarctic nesting ducks are not well known (MacCluskie and Sedinger 1999). Knowledge of the incubation behaviors of subarctic nesting Common Goldeneye (*Bucephala clangula*) populations in North America is particularly limited. There is some indication that incubation behavior may vary with weather, body condition, and incubation day (Afton and Paulus 1992), but individual variation within and among females is often high (Ringelman et al. 1982, Flint and Grand 1999, MacCluskie and Sedinger 1999).

Selection pressures such as ensuring embryo development, maintaining female energy balance, and minimizing predation risk may influence incubation behavior (Thompson and Raveling 1987, Afton and Paulus 1992, Flint and Grand 1999). It has been suggested that weather may not have as much influence on Common Goldeneye incubation because nests are located in cavities (Zicus et al. 1995). Relative to open nests, nest-boxes provide nearly complete protection from precipitation and have reduced convective heat loss. Reduced levels of nest predation have been documented for Wood Ducks (*Aix sponsa*) (Manlove and Hepp 2000) compared to other waterfowl species, and the low incidence of nest predation in our population (Taylor unpub. data) implies that factors other than predator avoidance may have a greater influence on incubation rhythms and recess characteristics for cavity nesters.

The breeding season for Common Goldeneyes in Interior Alaska begins in late April (Taylor unpub. data) when wetlands are still frozen and minimum daily temperatures may dip below 0°C. During incubation, temperatures may reach 30°C or more and daylight is nearly continuous. We hypothesized that the combination of high diurnal and daily variation in ambient temperatures, long photoperiods, and a short breeding season may result in different incubation patterns than have been previously reported in this species. Common Goldeneyes in more southern locations typically begin nesting in late March to early May, with most beginning in early to mid April. Increased ambient temperatures and precipitation have previously been shown to affect recess behavior in waterfowl (Afton and Paulus 1992). Further, recess initiation was almost completely limited to daylight hours in Common Goldeneyes in Minnesota (Zicus et al. 1995) and Ontario (Mallory and Weatherhead 1993).

We studied nest attendance in Common Goldeneyes in Interior Alaska to compare incubation patterns to those found in more southern populations, as well as to other species of similar size. We hypothesized that nest-boxes may reduce the effects of ambient temperature and precipitation on incubation and recess characteristics due to the protected nature of such nests relative to other species. We investigated the potential relationship between average timing of daily recesses and ambient temperature, daily precipitation, female experience, and incubation period. We hypothesized that older females would have more regular patterns and that incubation behavior may vary with stage of incubation. We also predicted that clutch size, female breeding experience, maximum daily temperature, precipitation, and day of incubation may influence recess length and frequency. Previous studies have determined that recess initiation times are almost exclusively during daylight hours (Mallory and Weatherhead 1993, Zicus et al. 1995) therefore, we expected nearly continuous daylight to increase the range of recess initiation times during the day. We compared mean incubation constancy, number of recesses, and recess length to levels reported for other populations.

METHODS

We conducted our study in central Alaska on the Chena River State Recreation Area during the summers of 2002-2003. The study area encompassed approximately 102 km^2 along the north and middle forks of the Chena River. Nest-boxes (n=150) were located on or near wetlands associated with the Chena River at heights of 3-7m. The sites were dominated by mixed stands of white spruce (*Picea glauca*), paper birch (*Betula papyrifera*), black spruce (*Picea mariana*), and balsam poplar (*Populus balsamifera*). Weather data were acquired from the Two Rivers National Weather Service weather station (64° 53' 55"N latitude, 146° 24' 42"W longitude), located within our study area. During the nesting period (late April to early July), the period from dawn to dusk was exceptionally long. Sunrise occurred between 03:00 and 05:00 and sunset occurred between 22:00 and 24:00 with a period of twilight during the intervening period.

During the breeding season, we checked nest boxes weekly to determine occupancy. We revisited active nests every 1 to 3 days to determine egg-laying rates and to capture adult females on the nest. All eggs were candled during each visit to determine stage of incubation (Weller 1956), and we estimated hatch dates, assuming that incubation began on the day the last egg was laid and lasted a minimum of 28 days (Eadie et al. 1995). Egg-laying was assumed to occur at a rate of 1 egg every other day; if the clutch size increased faster, nest parasitism was suspected (Eadie et al. 1995). We captured most females during egg-laying and again during mid to late incubation to verify identification of banded birds, and obtain better estimates of hatch dates.

We monitored incubation constancy (percent of time spent on the nest) as well as the timing, number, and duration of daily recesses using 2 types of temperature data loggers enclosed in artificial eggs. In 2002, we used artificial eggs (Advanced Telemetry Systems, 470 First Avenue North, Isanti, MN) containing a thermistor and a radio-transmitter to monitor nest temperatures. Four nests on a single pond were selected for instrumentation to enable reception by a single receiver. Eggs transmitted temperature readings continuously and the nearby receiver monitored each egg's transmissions for 30 seconds individually. The average temperature over the 30 second interval was then stored in a data recorder and downloaded biweekly.

In 2003, artificial eggs (n=20) contained modified HOBO StowAway Tidbit data-loggers (Onset Computer Corporation, 470 MacArthur Blvd, Bourne, MA) set to record the nest temperature every 2 minutes. To increase sensitivity, the loggers were not enclosed in the normal factory waterproof case, allowing the thermistor to be exposed to the airspace inside the egg. We affixed the loggers to a cardboard insert to prevent movement of the logger during egg rotation and partially filled the eggs with silicone caulk to approximate the weight (65-70g) of a normal Common Goldeneye egg.

In 2002, loggers were installed at the onset of incubation, but in 2003 we initially placed loggers in nests soon after clutch initiation to allow monitoring of egg-laying behavior. However, predators, likely red squirrels (*Tamiasciurus hudsonicus*), destroyed several eggs (n=4). We delayed the installation of the remaining loggers until near the onset of incubation after which logger loss was greatly reduced. Years were combined for analysis. All procedures were approved by the Institutional Animal Care and Use Committee at the University of Alaska, Fairbanks (IACUC #02-20).

The start of incubation was defined as the day when the female spent more than 12 hours on the nest without a break, and the day of the incubation period was estimated using two methods. If a datalogger had been installed during egg-laying, the beginning of incubation could be readily identified by visual inspection of the nest temperature data. If the datalogger was installed after the onset of incubation, the day of incubation was estimated by numbering backwards from hatch. We assumed a 30 day incubation period which was the average for nests with complete incubation records. We included the entire incubation period in our calculations.

To identify recesses, we created a program in R (R Development Core Team 2003) to aid in the analysis of the daily temperature data. This method was validated against tabular data (Yerkes 1998). Recess initiations or recess terminations were assumed when the temperature changed ≥2.0°C within four consecutive intervals (8 minutes). This sequence of temperature changes helped distinguish between true recesses and comfort movements. We validated our recess identification criteria by recording actual departure times from flushed and captured birds (n=24) and comparing these times to those recorded by the data loggers. We estimated that recess times are accurate to ±4 min because nest temperatures were observed to change within 1 full interval after the female entered or exited the nest-box. Recesses initiated within 2 hours of researcher disturbance were excluded from analysis.

STATISTICAL ANALYSIS

We used linear regression models (PROC REG, SAS Institute 1999) to investigate hypotheses involving variation in incubation constancy, recess length, and number of daily recesses relative to the potential explanatory variables that we recorded. Maximum daily temperature, daily precipitation, day of incubation, clutch size, female experience, and all biologically relevant two-way interactions were included in our initial general models. Female experience was entered as a binary variable with first-time breeders receiving a value of 0 and females that bred in previous years receiving a value of 1, all other variables were continuous. We used PROC CORR (SAS Institute 1999) to identify and remove highly correlated explanatory variables using the Spearman's correlation coefficient at $P = 0.05$.

To account for the circular nature of diurnal data, we addressed hypotheses concerning mean recess timing using circular statistics (Fisher and Lee 1992, Fisher 1993, Borgioli et al. 1999). To investigate the potential effects of female age and incubation stage on the average initiation time of recesses, we separated the data into 8 groups: first-time breeders during each of 4 weeks of incubation, and experienced breeders during each of 4 weeks of incubation (Anderson and Wu 1995). The distributions of recess initiation times for these eight groups were then displayed graphically using rose diagrams and we tested the assumption of a von Mises distribution. We then performed tests for differences among the means and the concentrations of the eight groups (Fisher 1993).

To examine the effects of daily precipitation, maximum daily temperature, and their interaction on mean recess time, we maximized the circular-linear regression log-likelihood equation proposed by Fisher and Lee (1992) and Fisher

(1993). We used likelihood ratio tests to compare these models and selected the best model based on comparisons to the X^2 critical value (Borgioli et al. 1999).

Average values for incubation constancy, recess duration, and number of recesses were calculated for comparison with other studies. We used only days with complete records to calculate incubation constancy and number of recesses. All means are reported ± SE.

RESULTS

We collected data from 20 female Common Goldeneyes in 2002 and 2003 combined (n = 515 days). Average incubation constancy, defined as the percentage of time spent on the nest, was 79.8 ± 0.3%, and the duration of the incubation period averaged 30 days (range = 28-32). The best approximating model that attempted to predict the proportion of time spent incubating (r^2 = 0.18) contained a negative effect of the interaction between maximum temperature and age, and a positive effect of clutch size (Table 1).

The number of recesses in each 24 hour period beginning at midnight averaged 2.9 ± 0.05 (range = 1-9) and most (88%) were initiated between 09:00 and 22:00 ADT (mean = 15:00). The remaining recess initiation times were separated into 3 groups: 22:01-24:00 (2%), 00:01-04:00 (2%) (between sunset and sunrise), and 04:01-08:59 (8%). The number of daily recesses increased with incubation day (r^2 = 0.12) (Table 1) while no other variables were entered into the model at P = 0.05.

Recess length averaged 100.7 ± 1.5 min (n = 1449, range = 8-524 min) and the best approximating model indicated that recess length was negatively influenced by the interaction between incubation day and clutch size, and female experience, while maximum daily temperature positively affected the length of recesses (Table 1). However, this model explained little variation in the data (r^2 = 0.08).

Comparisons of the rose diagrams by experience and week of incubation (n=8) revealed no apparent difference in the distribution of daily recesses between experienced females and first-time breeders in relation to week of incubation (Fig. 1). A test for a common mean direction (Fisher 1993) between these 8 distributions indicated that there was no evidence to support a difference between mean recess timings ($P > 0.999$). We also tested for equality of concentration parameters (κ) for all 8 groups and found no evidence for a difference ($P = 0.98$).

We found no support for models explaining variation in mean timing of recesses within days. Likelihood ratio tests indicated that models containing maximum daily temperature, daily precipitation, and the two-way interaction term were not significant at $P = 0.05$. We rejected the full model ($X^2_3 = 1.88$) and the reduced models containing maximum daily temperature ($X^2_1 = 1.96$) and daily precipitation ($X^2_1 = 1.92$). There was no evidence to support the selection of a model with any of the measured parameters.

DISCUSSION

Incubation characteristics in our study (80% constancy, 2.9 recesses/day, 101 minutes/recess) were comparable to a Common Goldeneye population in Ontario, Canada where, on average, females spent 81% of the day on the nest, took 2.7 recesses a day, and spent an average of 114 min off the nest during each recess (Mallory and Weatherhead 1993). The average timing of recesses within the day in our population was not related to female experience, incubation stage, maximum daily temperature, or daily precipitation; and incubation components were not related to any of the variables we measured. Our data suggest that incubation constancy, recess length, and recess duration do not vary with latitude.

Increased day length may increase the range of recess initiation times. Nocturnal recesses (00:01 to 04:00 ADT) represented 1% of those taken in this sample of Common Goldeneyes and appeared to be unique in comparison to previously reported patterns. While most recesses (88%) occurred between 09:00 and 22:00 ADT, recesses were initiated at all hours of the day in our population which had not been previously reported in this species. Zicus et al. (1995) found that most recesses occurred between 09:00 and 19:00 and less than 1% of recesses occurred between sunset and sunrise. Similarly, Mallory and Weatherhead (1993) found that recesses occurred between 07:00 and 20:00. A nocturnal recess was only observed on 1 occasion out of a sample of 16 incubating females. While only diurnal recesses have been reported in

Northern Shovelers (*Anas clypeata*) (Afton 1980) and were assumed for White-winged Scoters (*Melanitta fusca*) (Brown and Fredrickson 1987), nocturnal recesses have been reported for Ring-necked Ducks (*Aythya collaris*) in Minnesota (Hohman 1986). We believe that the long days during the incubation period broadened the range of nest breaks and facilitated recesses during the late evening and early morning hours. This may be the case for Northern Shovelers nesting at Minto Flats, Alaska as well (MacCluskie and Sedinger 1999). This increased range of nest recesses within the day apparently allows females more plasticity in incubation rhythms than is possible at more southern latitudes. Knowledge of the distribution of the timing of nest breaks could be used to decrease the chance of disturbing females during incubation by visiting nests during the middle of the solar day when recesses are most likely to occur. Conversely, female capture rates would likely increase during the late evening and early morning hours.

Higher ambient temperatures often decrease nest attendance in a variety of species (Afton and Paulus 1992), including Common Goldeneyes (Mallory and Weatherhead 1993). This could be the result of reduced cooling rates of the eggs at higher temperatures, or increased female heat stress. The number of daily recesses has previously been found to be positively related to the day of incubation in Common Goldeneyes (Zicus et al. 1995) as well as Northern Shovelers (Afton 1980) and White-winged Scoters (Brown and Frederickson 1987). The physiological cost of rewarming eggs could also be higher for those females with larger clutches (Afton and Paulus 1992). If this cost is considerable, it may pressure females with large clutches to take fewer, longer breaks to decrease the overall cost of rewarming the eggs (Drent 1973). We detected only a very weak negative effect of the interaction of incubation day and clutch size on break length, but we believe that this issue deserves more attention, particularly for species like Common Goldeneyes with high levels of nest parasitism. We estimate that at least 6 of the nests we instrumented were parasitized by other female Common Goldeneyes.

We also did not detect an effect of precipitation on any of the components of incubation, which is likely due to the enclosed nature of nest-boxes. Open nesters increase attentiveness during rain showers (Afton 1980, Afton and Paulus 1992), although there could be a reduction in food availability during precipitation events (Sjoberg and Danell 1982) which could discourage recess initiation if food acquisition motivates nest breaks. Zicus et al. (1995) suggested a positive relationship between incubation constancy and quality of the foraging territory, indicating that food acquisition may play a role in recess behavior. It has also been hypothesized that females in better condition have a higher constancies and shorter incubation periods (Zicus et al. 1995), although Manlove and Hepp (2000) found no relationship between incubation constancy and body mass in Wood Ducks. Female condition and ability to obtain sufficient food resources during incubation could be very important in determining incubation behavior, and their effects should be explored. In our study we did not have a sufficient sample of females with body condition indices to explore this hypothesis.

Others have hypothesized that female body condition and food acquisition may also play an important role in female nest attendance in Common Goldeneyes (Mallory and Weatherhead 1993) as well as other species (Afton and Paulus 1992, MacCluskie and Sedinger 1999). Females in this study were captured at various stages of incubation and insufficient numbers were captured at the same stage of incubation to include body condition in the analysis. Increased effort to catch females at similar times during incubation, and again at hatch, would allow comparisons between body condition and incubation behavior. Methods exist to simultaneously measure female mass loss and nest attendance (Mallory and Weatherhead 1993) which allows continuous monitoring of mass loss in conjunction with nest attendance. Food resource sampling could also be conducted to address habitat quality issues. Aquatic invertebrates were collected concurrently with another study (see Chapter 2), but the sub-sample containing monitored females with invertebrate resource data was insufficient for analysis. Future studies should consider both of these potential explanatory variables.

It may also be useful to measure ambient temperature and nest temperature simultaneously to determine if individual microclimatic effects determine nest attendance behaviors. Females may not be responding to the coarse-scale variables that we measured such as maximum daily temperature and precipitation as measured at one central location in the study site. Logically some nest-boxes may heat sooner than others, or stay warmer longer due to variations in the amount of overhead cover, aspect of the box, or some other finer-scale variable. The low cost and simplicity of dataloggers may help increase sample sizes in the future. We suggest that a broad scale study with larger sample sizes is necessary to establish if the incubation patterns reported to this point are specific to Common Goldeneyes and to determine if other habitat and female specific variables influence incubation behaviors.

We suggest that female incubation patterns may be due to unmeasured endogenous cues, or nest-specific microclimate variables. The lack of strong inference in this study indicates that other factors are likely responsible for variation in incubation behaviors. Future research should consider variables such as female body condition, nest attributes, food-availability, and disturbance in an attempt to determine causal mechanisms. Possibly larger sample sizes and measurement of female specific variables will help identify the reasons for observed nest attendance patterns.

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LITERATURE CITED

Afton, A. D. 1980. Factors affecting incubation rhythms of Northern Shovelers. Condor 82:132-137.

Afton, A. D., and S. L. Paulus. 1992. Incubation and brood care in waterfowl, p. 62-108. *In* B. D. J. Batt, A. D. Afton, M. G. Anderson, C. D. Ankney, D. H. Johnson, J. A. Kadlec, and G. L. Krapu [eds.], The ecology and management of breeding waterfowl. Univ. Minnesota Press, St. Paul, MN.

Anderson, C. M., and C. F. J. Wu. 1995. Measuring location effects from factorial experiments with a directional response. International Statistical Review 63:345-363.

Borgioli, C., L. Martelli, F. Porri, A. D'Elia, G. M. Marchetti, and F. Scapini. 1999. Orientation in *Talitrus saltator* (Montagu): trends in intrapopulation variability related to environmental and intrinsic factors. Journal of Experimental Marine Biology and Ecology 238:29-47.

Brown, P. W., and L. H. Fredrickson. 1987. Time budget and incubation behavior of breeding White-winged Scoters. Wilson Bulletin 99:50-55.

Drent, R. H. 1973. The natural history of incubation. *In* Breeding biology of birds. (D. S. Farner, ed.) National Academy of Sciences, Washington D.C.

Eadie, J., M. Mallory, and H. Lumsden. 1995. Common Goldeneye (*Bucephala clangula*). *In* The Birds of North America, No. 170 (A. Poole and F. Gill, eds.) The Academy of Natural Sciences, Philadelphia, and the American Ornithologists' Union, Washington, D.C.

Fisher, N. I., and A. J. Lee. 1992. Regression models for an angular response. Biometrics 48:665-677.

Fisher, N. I. 1993. Statistical analysis of circular data. Cambridge, Great Britain.

Hohman, W. L. 1986. Incubation rhythms of Ring-necked Ducks. Condor 88:290-296.

MacCluskie, M. C., and J. S. Sedinger. 1999. Incubation behavior of Northern Shovelers in the subarctic: a contrast to the prairies. Condor 101:417-421.

Mallory, M. L., and P. J. Weatherhead. 1993. Incubation rhythms and mass loss of Common Goldeneyes. Condor 95:849-859.

Manlove, C. A., and G. R. Hepp. 2000. Patterns of nest attendance in female Wood Ducks. Condor 102:286-291.

R Development Core Team [online]. 2003. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. <http://www.R-project.org> (15 March 2004).

Ringleman, J. K., J. R. Longcore, and R. B. Owen Jr. 1982. Nest and brood attentiveness in female Black Ducks. Condor 84:110-116.

SAS Institute. 1999. The SAS system for Windows, version 8.0. SAS Institute Inc., Cary, North Carolina.

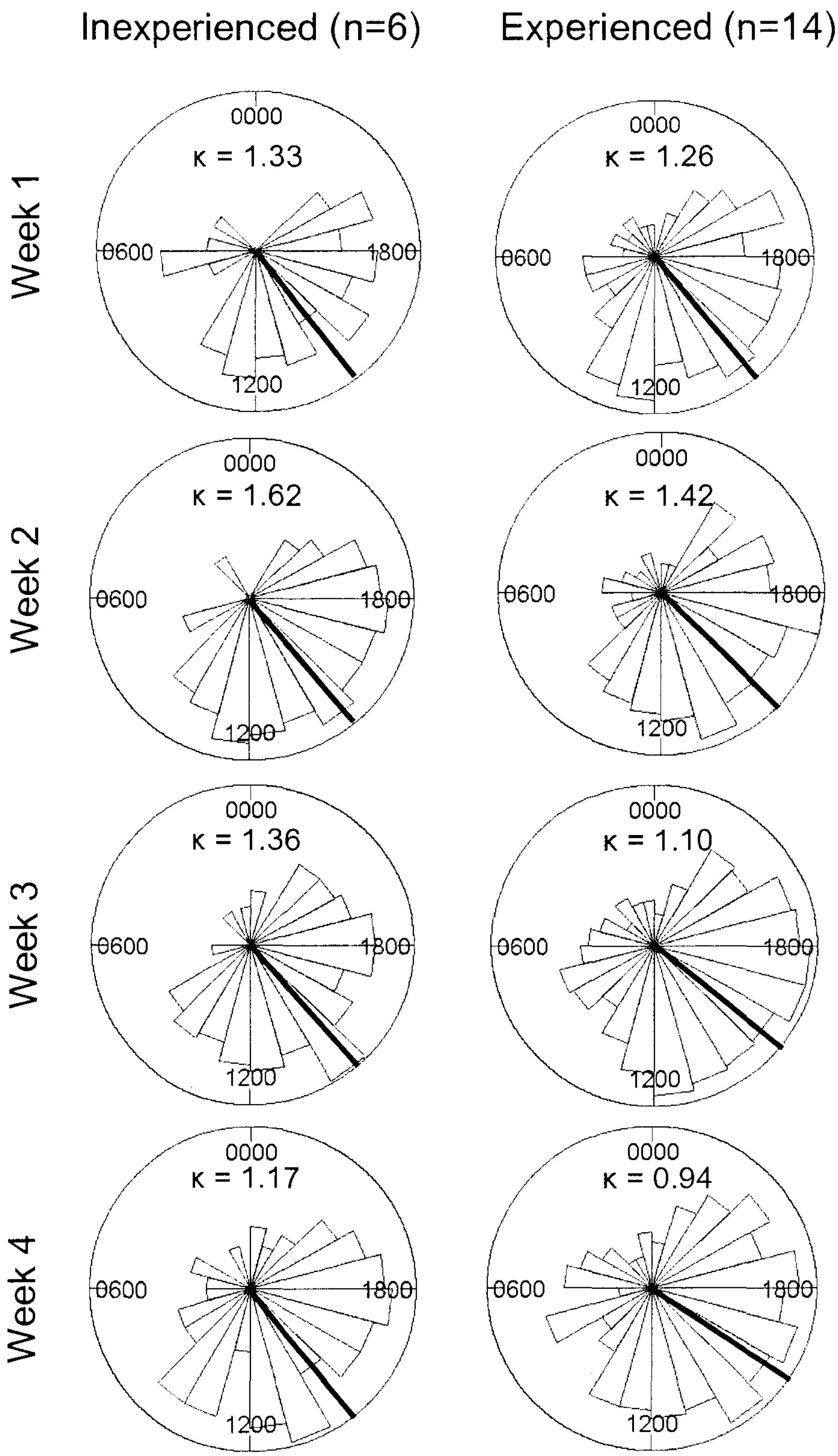
Thompson, S. C., and D. G. Raveling. 1987. Incubation behavior of Emperor Geese compared with other geese: interactions of predation, body size, and energetics. Auk 104:707-716.

Weller, M. W. 1956. A simple field candler for waterfowl eggs. Journal of Wildlife Management 20:111-113.

Yerkes, T. 1998. The influence of female age, body mass, and ambient conditions on Redhead incubation constancy. Condor 100:62-68.

Zicus, M. C., S. K. Hennes, and M. R. Riggs. 1995. Common Goldeneye nest attendance patterns. Condor 97:461-472.

Figure 1. Comparisons of recess initiation times of Common Goldeneyes nesting at the Chena River State Recreation Area based on female breeding experience and week of incubation. Each bar represents 1 hour, axis labels indicate time of day, times run counter-clockwise around the plot. Heavy line in each plot represents the mean timing of recesses and κ represents the concentration parameter of the distribution. Mean directions do not differ (P >0.999).



Inexperienced (n=6)
Experienced (n=14)
Week 1
Week 2
Week 3
Week 4
0000
0600
1200
1800
κ = 1.33
κ = 1.26
κ = 1.62
κ = 1.42
κ = 1.36
κ = 1.10
κ = 1.17
κ = 0.94

Table 1. Estimated of regression coefficients on a log scale (β ± SE) from the best approximating linear models for incubation constancy, number of daily recesses, and recess length for incubating Common Goldeneye females in the Chena River State Recreation Area, Alaska.

Dependent Variable	β parameter	Estimate ± SE
Incubation Constancy	Intercept	0.79 ± 0.01
	Max temp*experience	-0.0017 ± 0.00024
	Clutch size	0.0063 ± 0.001
Recess Number	Intercept	2.25 ± 0.09
	Incubation Day	0.043 ± 0.0055
Recess Length	Intercept	104.8 ± 6.14
	Incubation day*clutch size	-0.19 ± 0.019
	Max temp	1.67 ± 0.31
	Experience	-14.1 ± 3.17

CONCLUSIONS

Common goldeneye duckling survival in our study area was higher than previously reported for this species (Wayland and McNicol 1994, Eadie et al. 1995) and was also higher than reported for other sea ducks, such as spectacled (Flint and Grand 1997) and common eiders (Mendenhall and Milne 1985). The best approximating model indicated that survival increased linearly throughout the season, but this trend differed between years. Duckling survival was negatively affected by daily precipitation in both years. Future studies should examine other factors in depth, such as food availability and predation. Larger sample sizes may allow the detection of brood and clutch size effects if they exist.

Nest attendance patterns and incubation behaviors in this population were not related to weather, clutch size, female experience, or day of incubation. We believe that incubation behaviors may be related to other endogenous and microclimatic variables that we did not measure. Endogenous factors such as female body condition, or habitat variables such as food availability and nest microclimate, may explain larger portions of the variation in nest attendance in this species. The number of recesses, duration of individual recesses, and percentage of time spent on the nest were very similar to previously reported values from other studies. This indicates that some of the components of incubation are consistent across the range of this species. A small number of recesses did occur during the late evening and early morning hours which had not been previously reported for this species. This may be due to nearly constant daylight during the nesting season. In the future, studies should attempt to quantify female body condition by weighing females during different portions of the incubation period, or recording mass continuously by installing electronic balances in nest boxes. Food availability and habitat use should also be explored, possibly by combining radio-telemetry of nesting females with invertebrate collections in feeding areas. Finally, nest specific temperatures, and other female and nest specific variables such as clutch size and disturbance could be examined to potentially explain some of the variation in nest attendance behaviors.

APPENDIX A.

During brood relocations and duckling counts, we also recorded the location of the brood with a hand-held GPS unit. We then displayed the points on a NAD27 topographic map and identified the nest location, dates each brood was seen at each point, and locations where invertebrates were collected. A map was produced for each brood during each season indicating brood movements. Brood number corresponds to the nest-box number from which the brood hatched. Table A-1 summarizes general information about each brood and its corresponding map. Aerial photographs were unavailable and satellite images were too out of date to be used for this descriptive summary.

When ducklings reached two weeks of age, invertebrates were collected at both the nest location and the brood location of a subset of the broods each year to provide an index of food abundance. These collection locations are identified by a yellow 'X' on the map. We used activity traps similar to those used by Murkin et. al (1983) to collect invertebrates by placing 5 traps in both the nest and brood-rearing wetlands. Traps were retrieved after 48 hours, contents were passed through a 1mm sieve, and the invertebrates were stored in 70% ethyl alcohol. In the lab, invertebrates were sorted to family if possible, measured to the nearest millimeter, and counted. These data are presented as one table per collection location with the contents of the 5 traps at each location combined. Broods with invertebrate data are identified in Table A-1. This sampling protocol may have limited utility due to the nature of brood movements. Some broods remained on a wetland for the entire 30 days, while others only spent 1 day in an area that was sampled. More frequent sampling would be required to adequately describe the invertebrate resources in the wetlands being used by these broods. The dates of relocations for each brood on a particular wetland is shown on the maps in Appendix A.

Table A-1. Relocation characteristics, female identification, and box number for broods observed during 2002 and 2003.

Box ID	Female Band Number	Female age	Hatch Date	Initial Brood Size	Number at Last Resighting	Date of Last Resighting	Number of Relocations	Number of Unique Relocations	Invertebrates Collected
2	756-18042	≥5	6/15/2002	7	1	7/4/2002	8	1	*
9	966-10039	≥6	6/14/2002	4	3	7/9/2002	3	2	*
13	756-18049	≥5	6/12/2002	8	8	6/27/2002	7	3	*
16	756-18077	4	6/11/2002	7	4	6/27/2002	2	2	*
22	1036-14470	3	6/12/2002	10	10	7/2/2002	11	1	*
51	756-18050	≥5	6/17/2002	7	6	6/30/2002	3	4	*
63	966-10003	≥6	6/7/2002	6	2	6/28/2002	9	2	*
64	966-10112	≥7	6/13/2002	6	4	7/20/2002	16	2	*
71	966-10115	≥7	6/17/2002	8	2	7/10/2002	6	3	*
87	756-18048	≥5	6/15/2002	6	5	7/14/2002	3	2	*
96	966-10001	≥6	6/10/2002	8	5	6/16/2002	3	3	
97	756-18062	≥5	6/22/2002	5	3	7/10/2002	7	3	*
111	966-10117	≥7	6/10/2002	7	3	6/29/2002	10	2	*
114	966-10007	≥6	6/13/2002	6	6	6/25/2002	2	2	

125	966-10114	≥7	6/19/2002	7	6
136	1036-14501	2	6/28/2002	5	3
138	756-18081	≥4	6/11/2002	5	3
3	1036-14576	≥2	6/13/2003	5	4
13	756-18049	≥6	6/3/2003	8	8
14	756-18078	5	6/9/2003	8	8
16	756-18077	5	6/4/2003	6	6
19	1036-14569	2	6/12/2003	11	10
22	1036-14470	4	6/15/2003	8	8
39	1036-14565	4	6/16/2003	3	3
41	756-18071	≥5	6/12/2003	12	11
43	756-18092	≥5	6/6/2003	8	8
44	1036-14462	5	6/16/2003	5	0
45	966-10537	≥7	6/10/2003	11	11
47	1036-14526	4	6/10/2003	11	7
51	756-18050	≥6	6/7/2003	7	3
53	1036-14583	2	6/19/2003	10	9
56	1036-14566	2	6/13/2003	6	6

7/3/2002	6	2	*
7/19/2002	3	2	
7/15/2002	6	2	*
7/11/2003	6	1	
6/11/2003	5	3	
6/27/2003	5	4	
7/16/2003	14	14	*
6/20/2003	3	2	
7/16/2003	13	2	*
7/12/2003	8	2	*
7/7/2003	12	4	*
6/14/2003	3	3	
7/7/2003	7	4	
6/21/2003	3	2	
7/7/2003	2	2	
7/10/2003	11	4	*
7/16/2003	9	2	*
7/6/2003	5	1	*

69	1036-14486	3	6/13/2003	10	8
72	966-10149	≥7	6/8/2003	9	6
83	1036-14580	2	6/22/2003	5	5
84	756-18046	≥6	6/11/2003	8	0
89	1036-14497	3	6/13/2003	7	6
96	966-10001	≥7	6/3/2003	7	2
97	756-18062	≥6	6/11/2003	6	5
106	1036-14567	2	6/17/2003	12	5
107	1036-14517	≥3	6/11/2003	9	9
108	1036-14571	2	6/19/2003	8	7
111	966-10117	≥8	6/6/2003	9	7
114	966-10007	≥7	6/2/2003	6	5
120	1036-14582	2	6/19/2003	5	1
121	1036-14570	≥2	6/18/2003	5	2
125	966-10114	≥8	6/7/2003	9	3
130	1036-14498	4	6/13/2003	7	7
132	1036-14575	2	6/20/2003	7	6
138	756-18081	≥5	6/7/2003	10	0

7/1/2003	4	3	
7/16/2003	13	5	*
6/29/2003	2	2	
7/10/2003	9	9	*
6/29/2003	3	3	
7/10/2003	9	3	*
7/10/2003	11	10	*
7/4/2003	2	2	
6/14/2003	2	2	
6/26/2003	3	3	
7/16/2003	16	2	*
6/16/2003	6	2	*
7/6/2003	4	1	
7/16/2003	13	2	*
7/16/2003	9	5	*
7/5/2003	6	5	*
7/16/2003	7	2	
7/16/2003	12	9	*

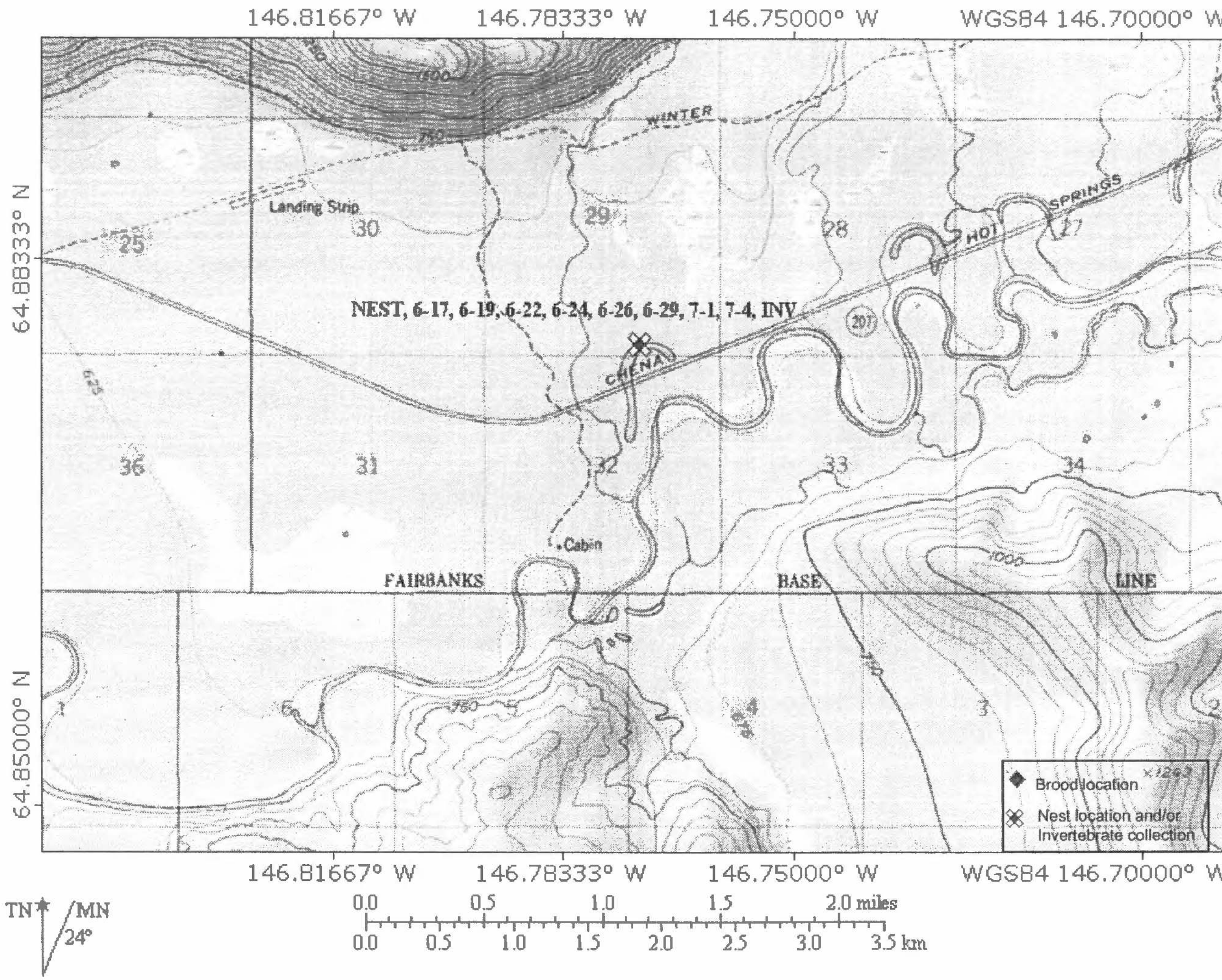


Figure A-1. Locations for brood 2 during the 2002 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

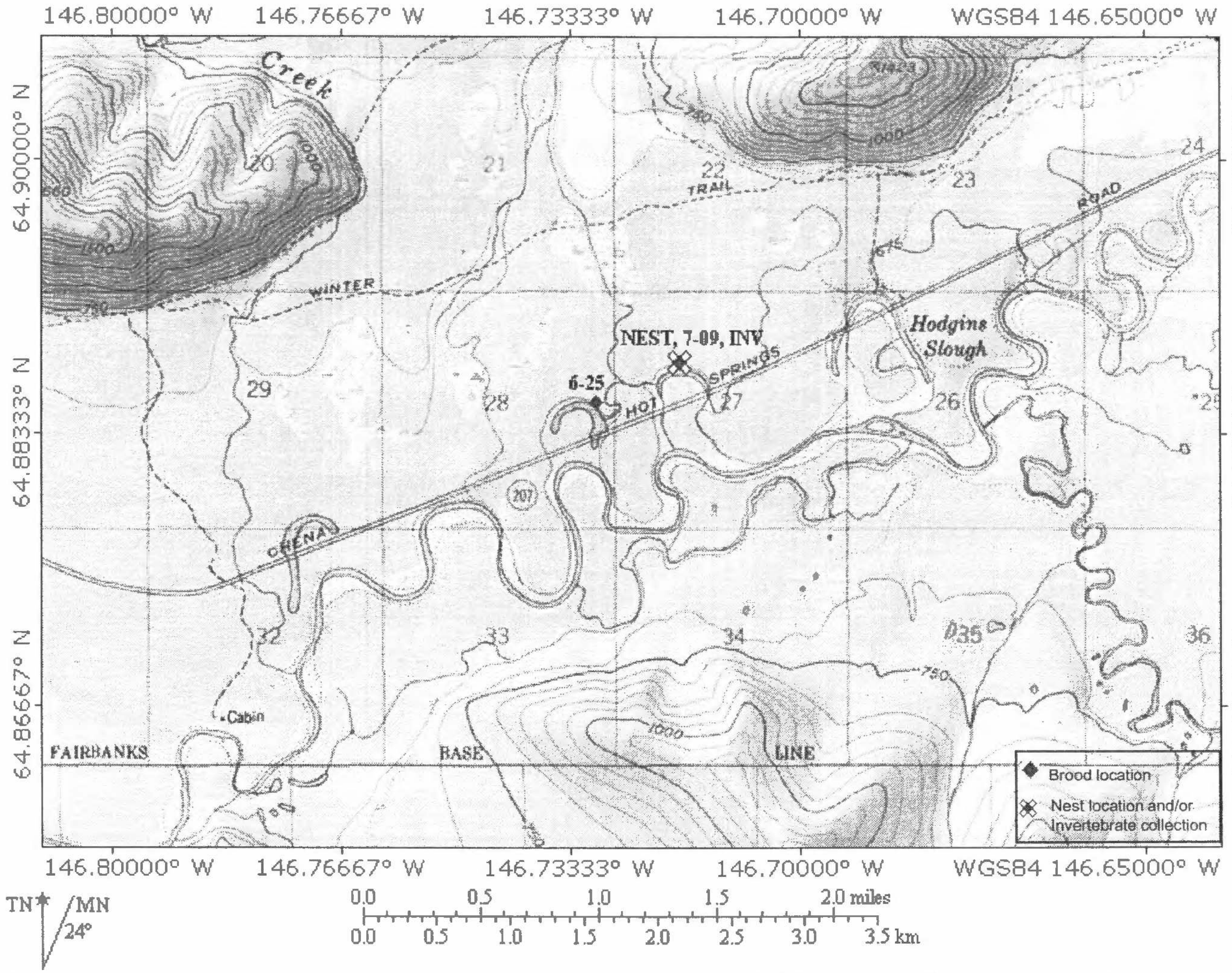


Figure A-2. Locations for brood 9 during the 2002 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

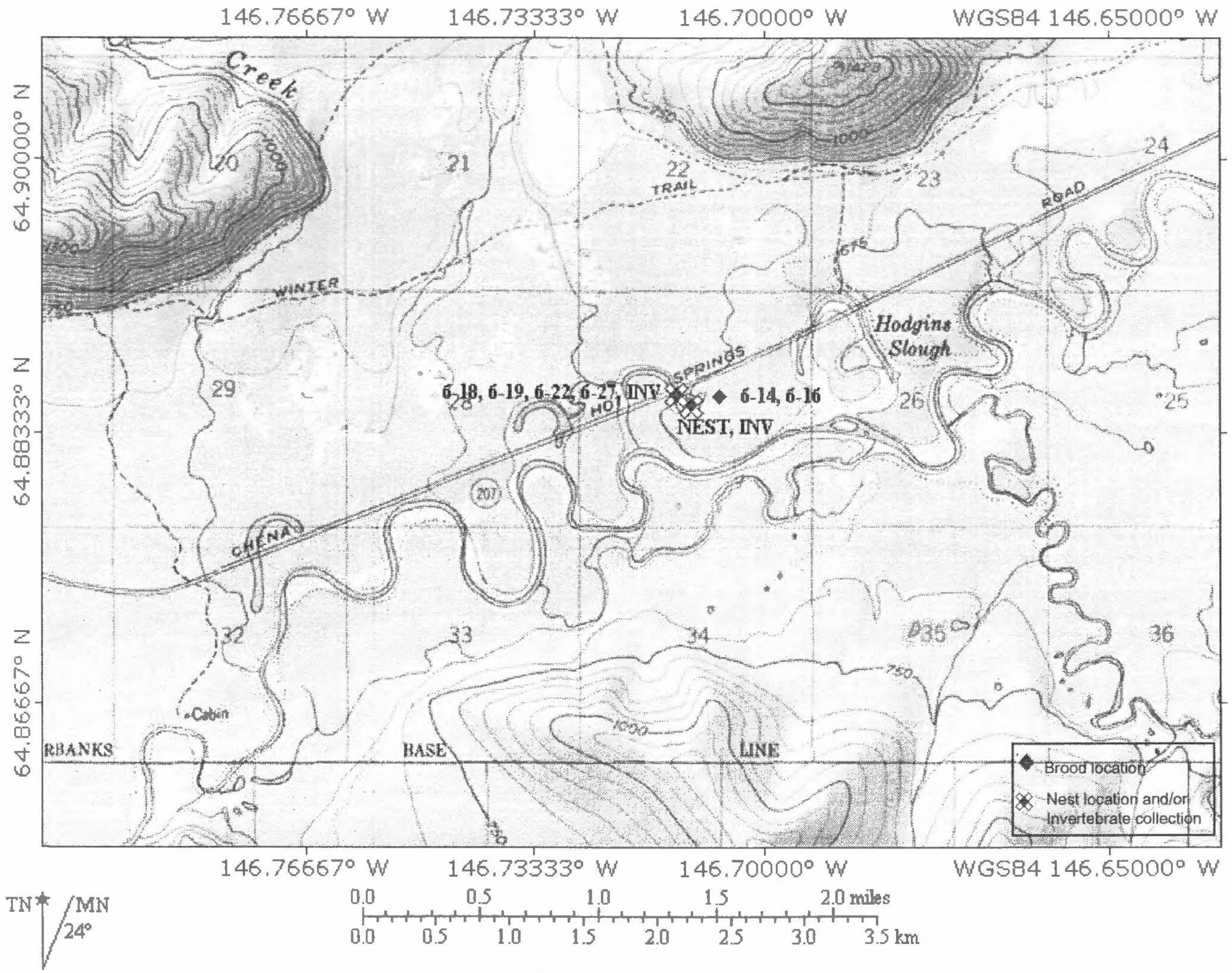


Figure A-3. Locations for brood 13 during the 2002 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

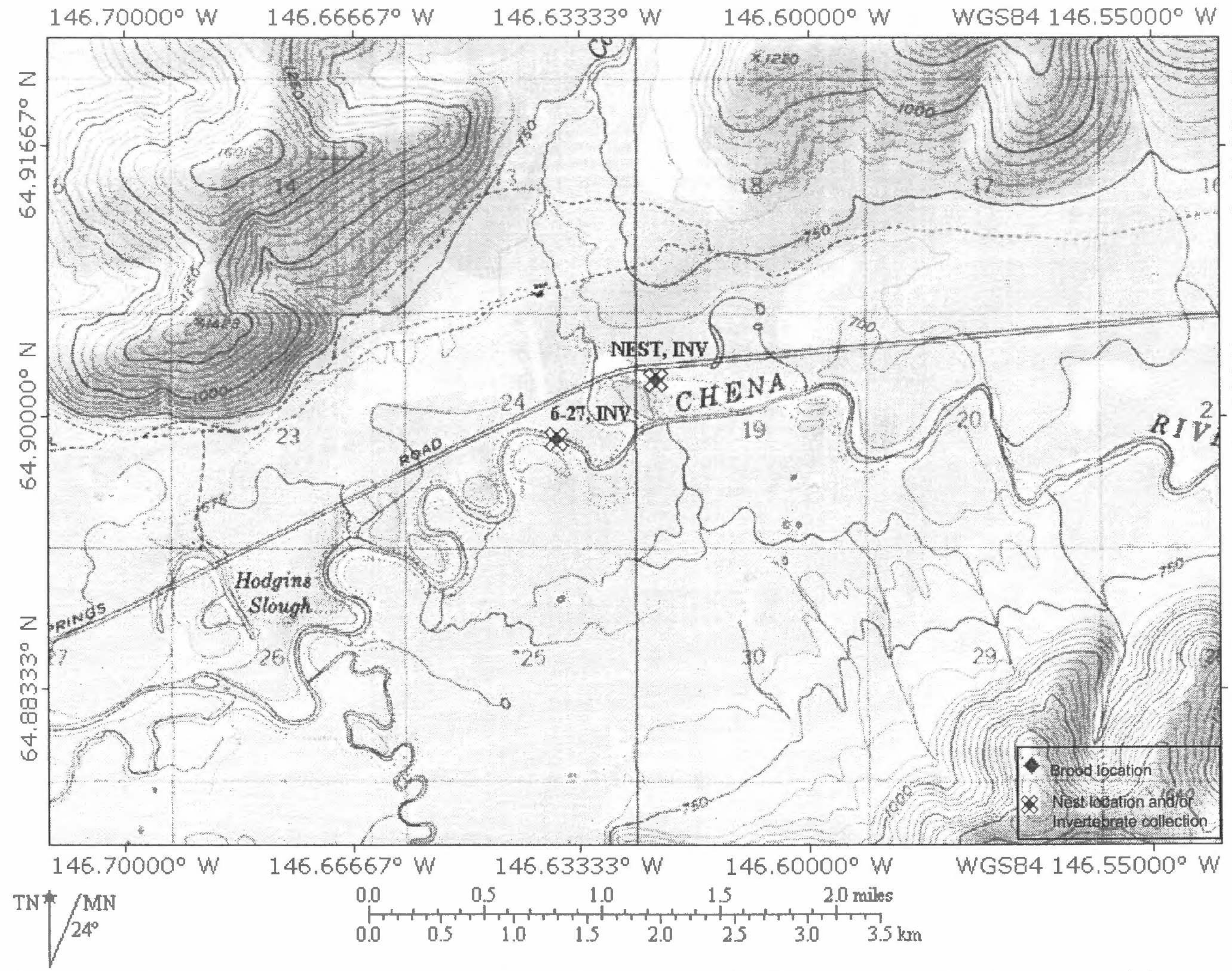


Figure A-4. Locations for brood 16 during the 2002 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

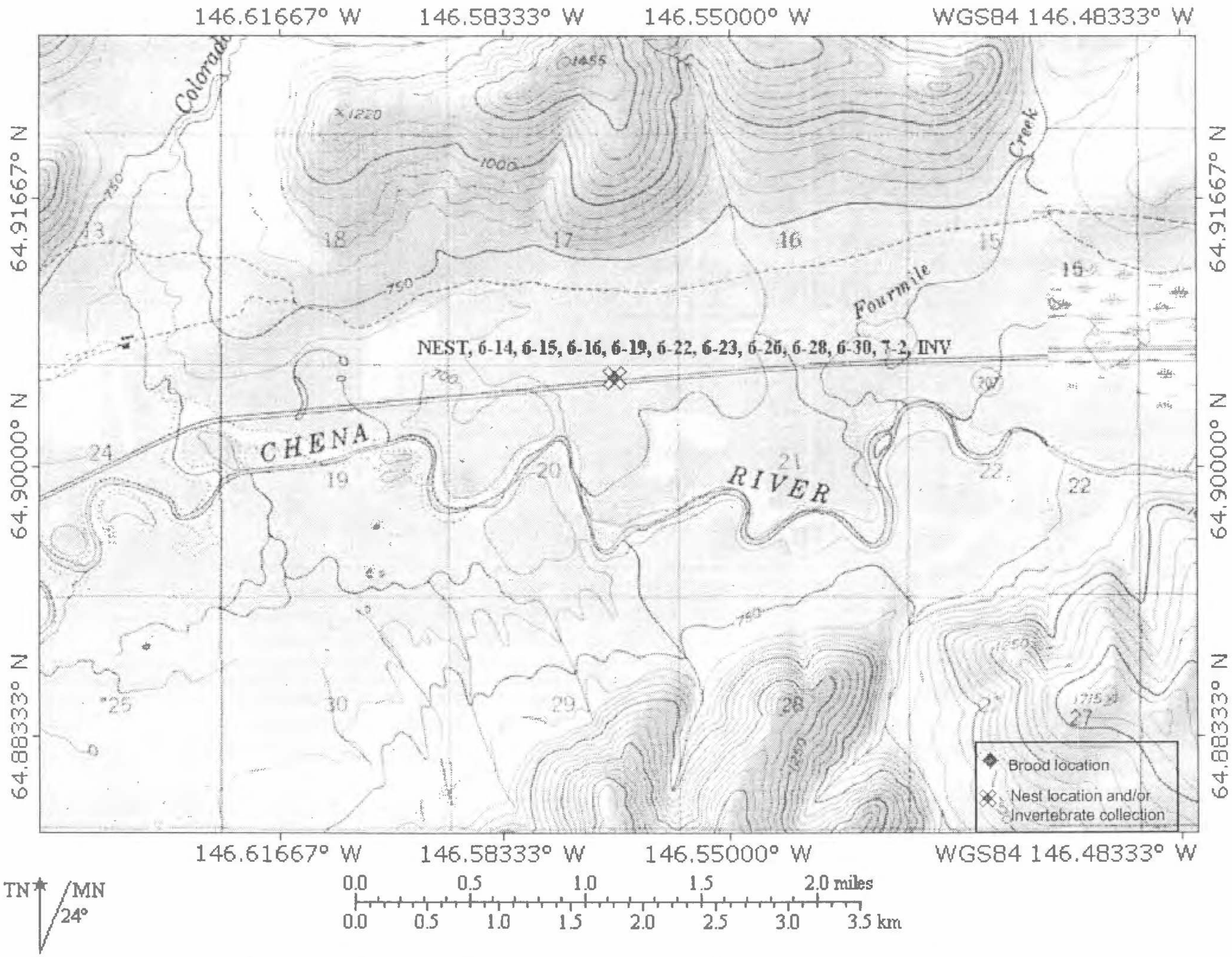


Figure A-5. Locations for brood 22 during the 2002 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

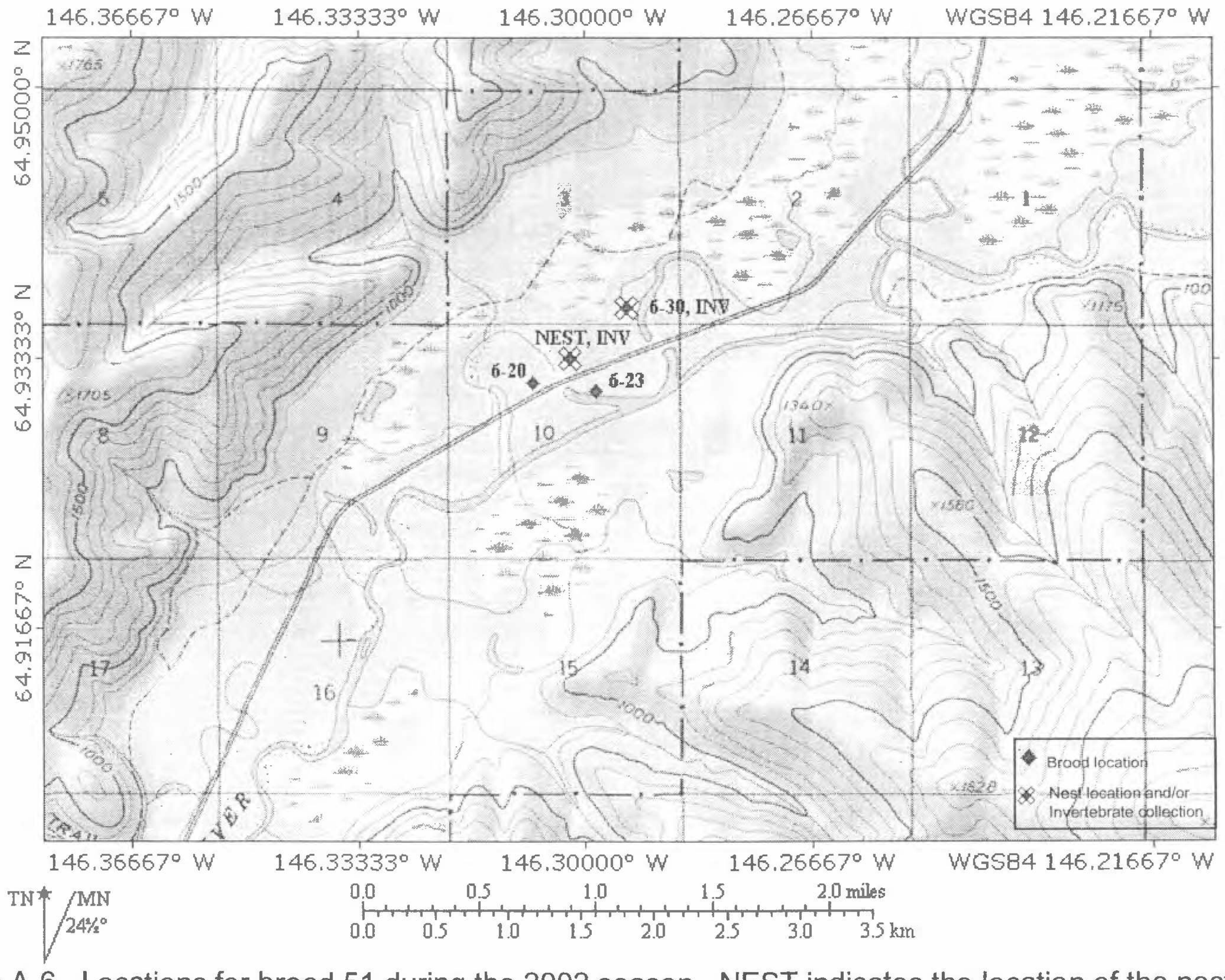


Figure A-6. Locations for brood 51 during the 2002 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

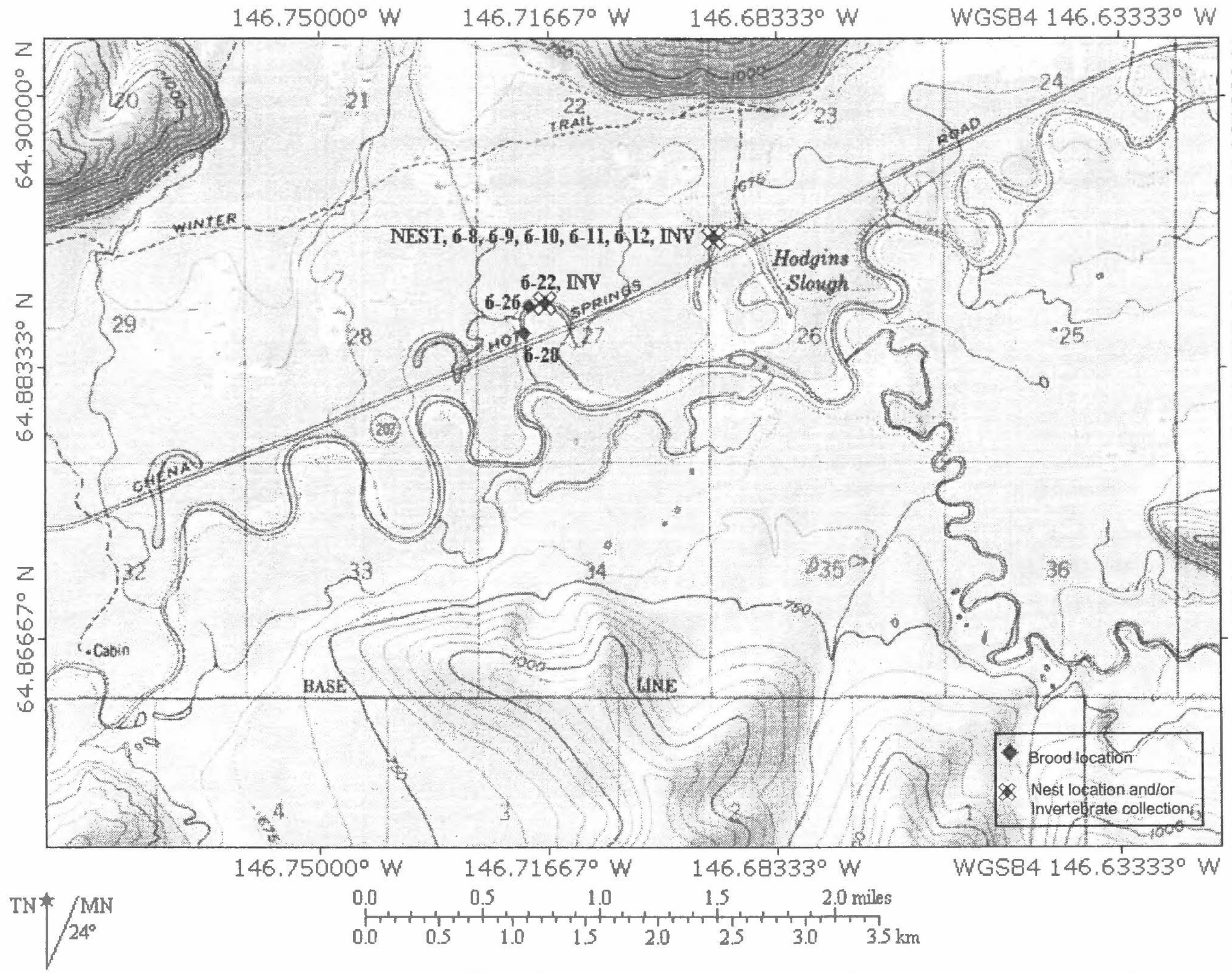


Figure A-7. Locations for brood 63 during the 2002 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

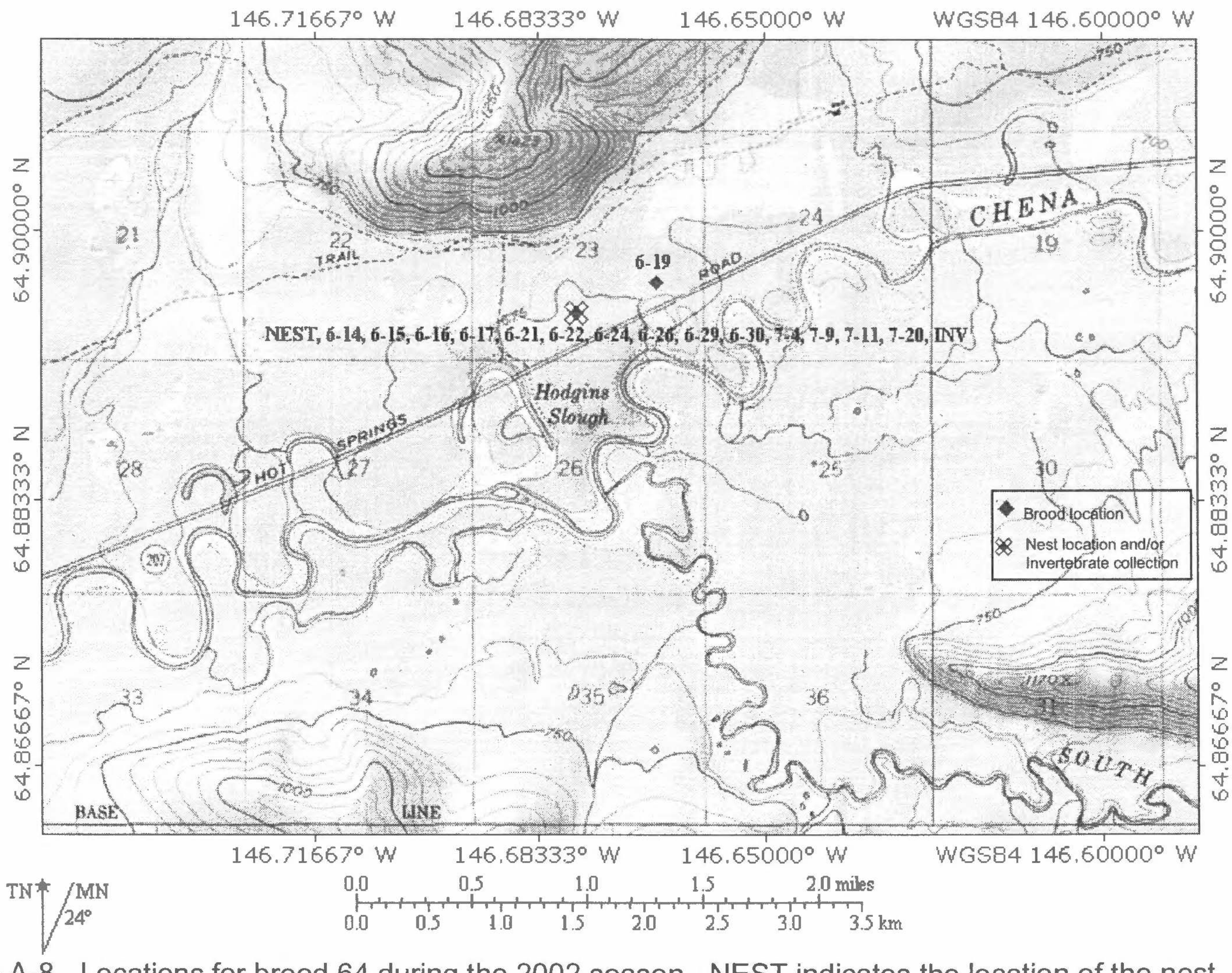


Figure A-8. Locations for brood 64 during the 2002 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

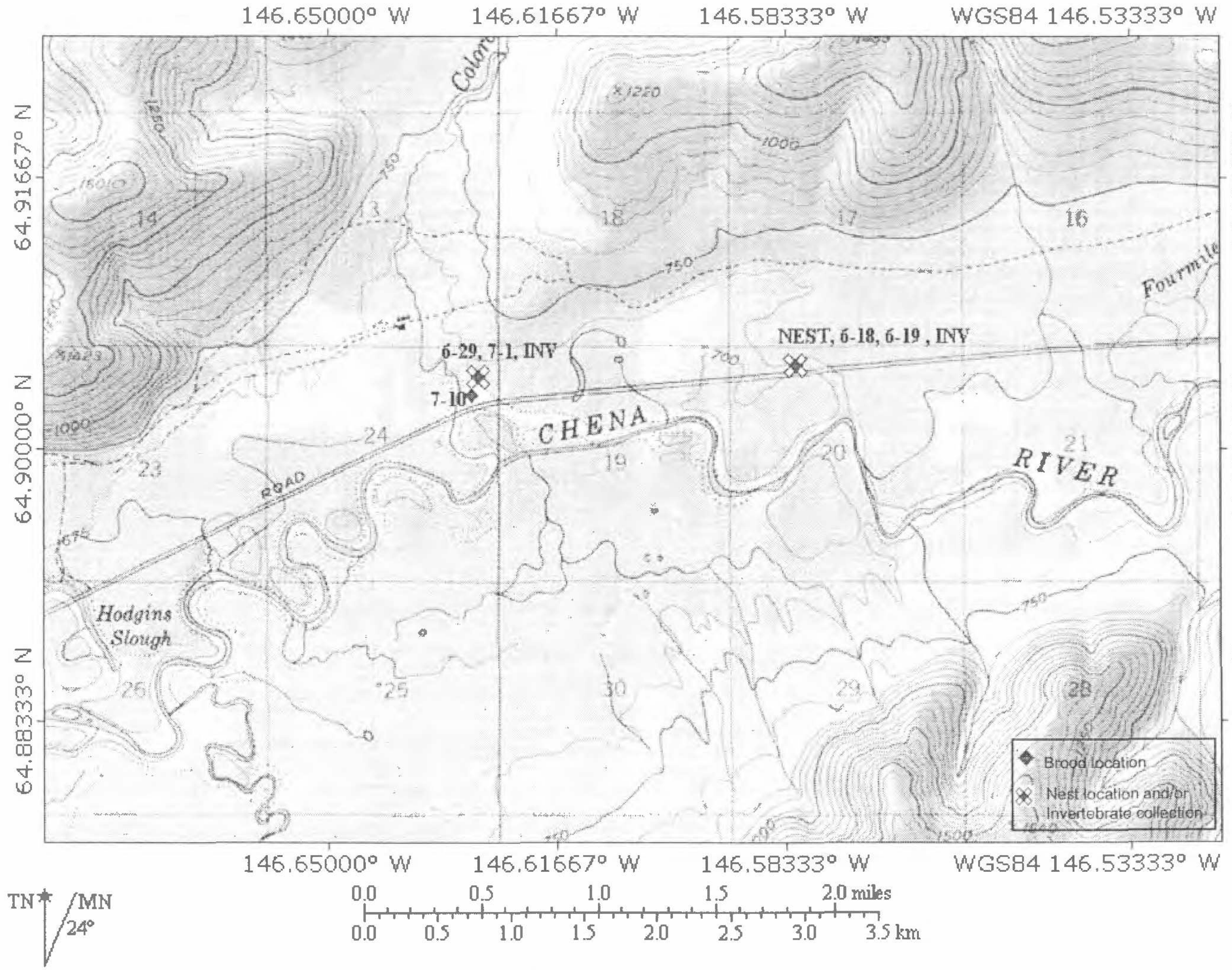


Figure A-9. Locations for brood 71 during the 2002 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

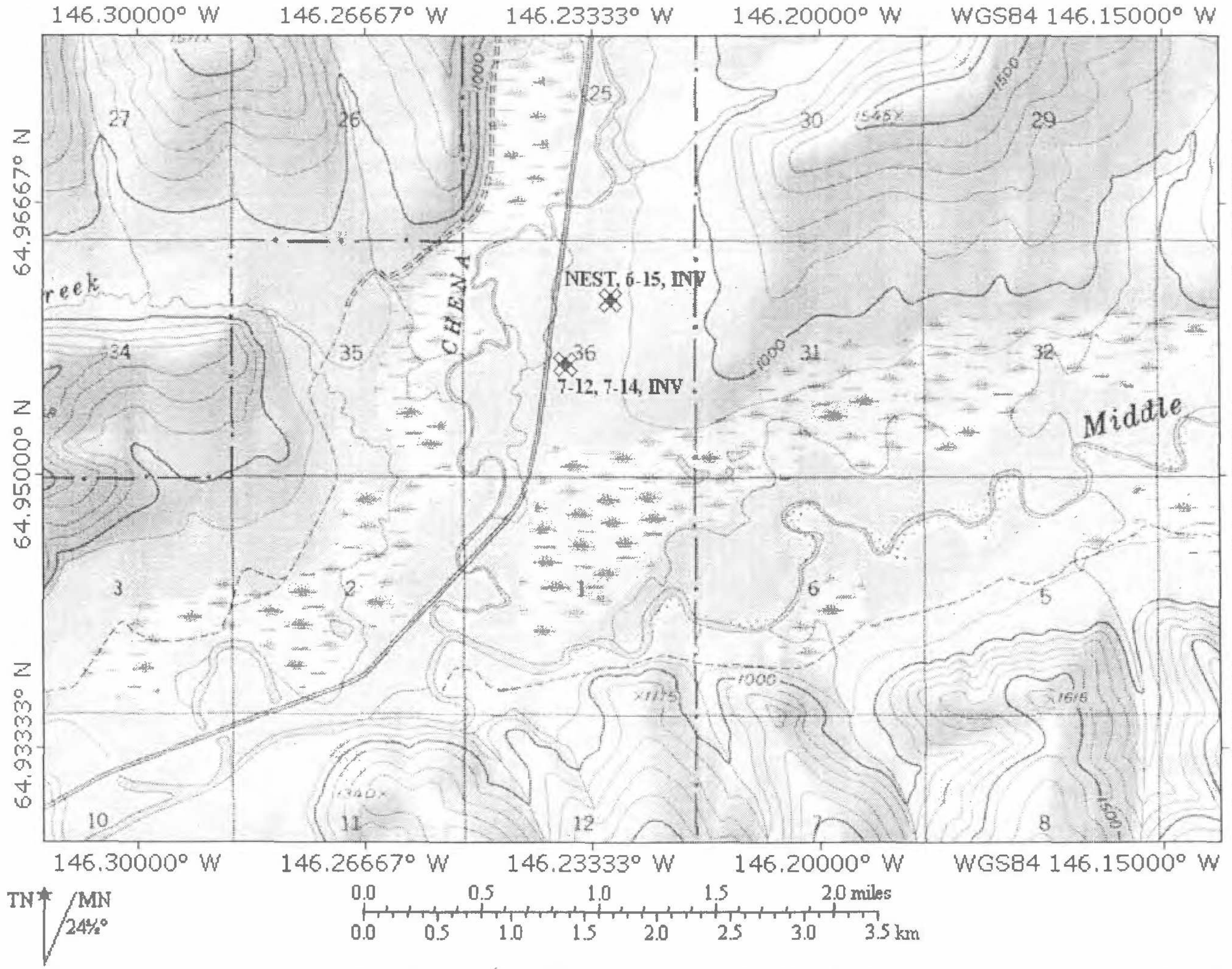


Figure A-10. Locations for brood 87 during the 2002 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

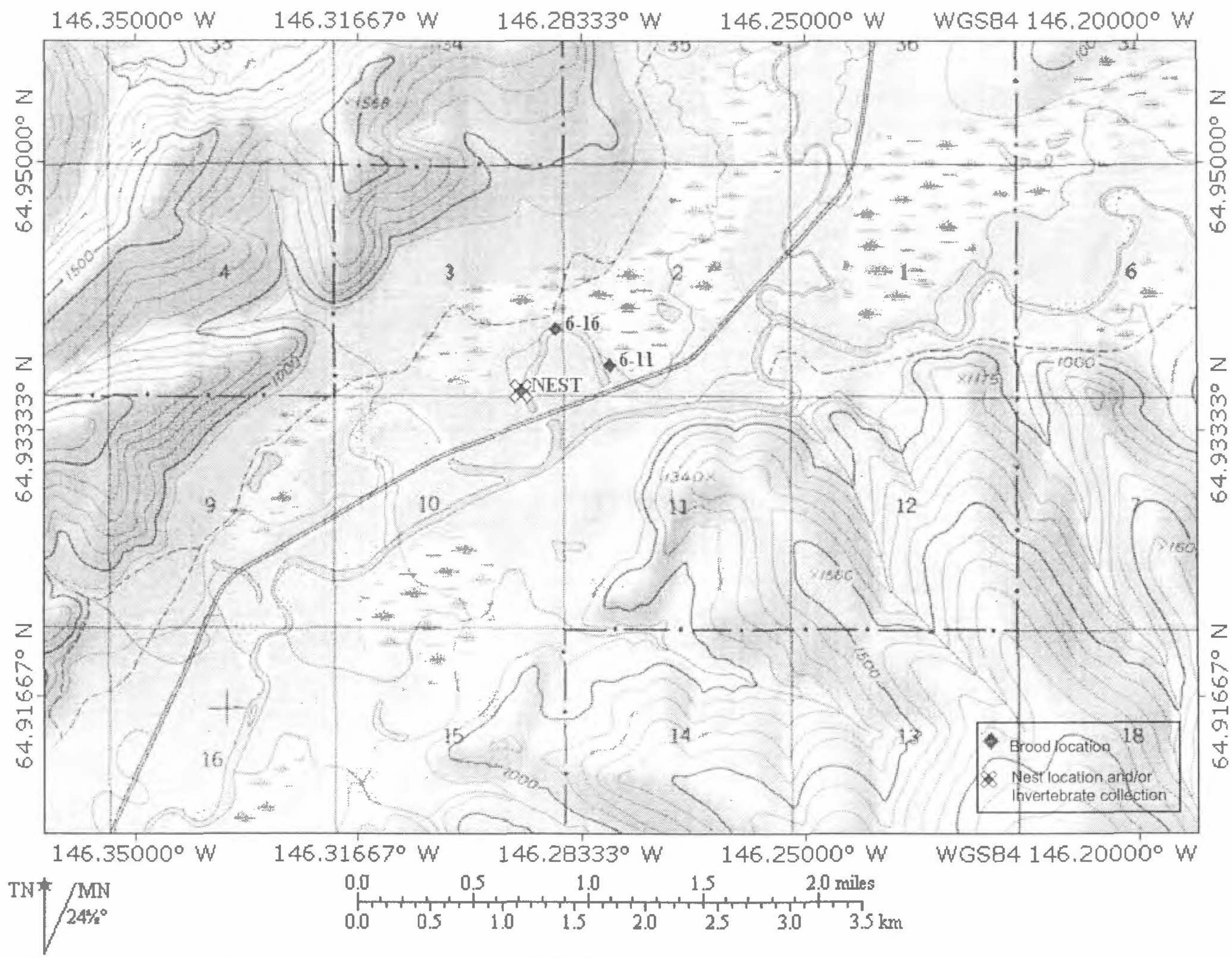


Figure A-11. Locations for brood 96 during the 2002 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

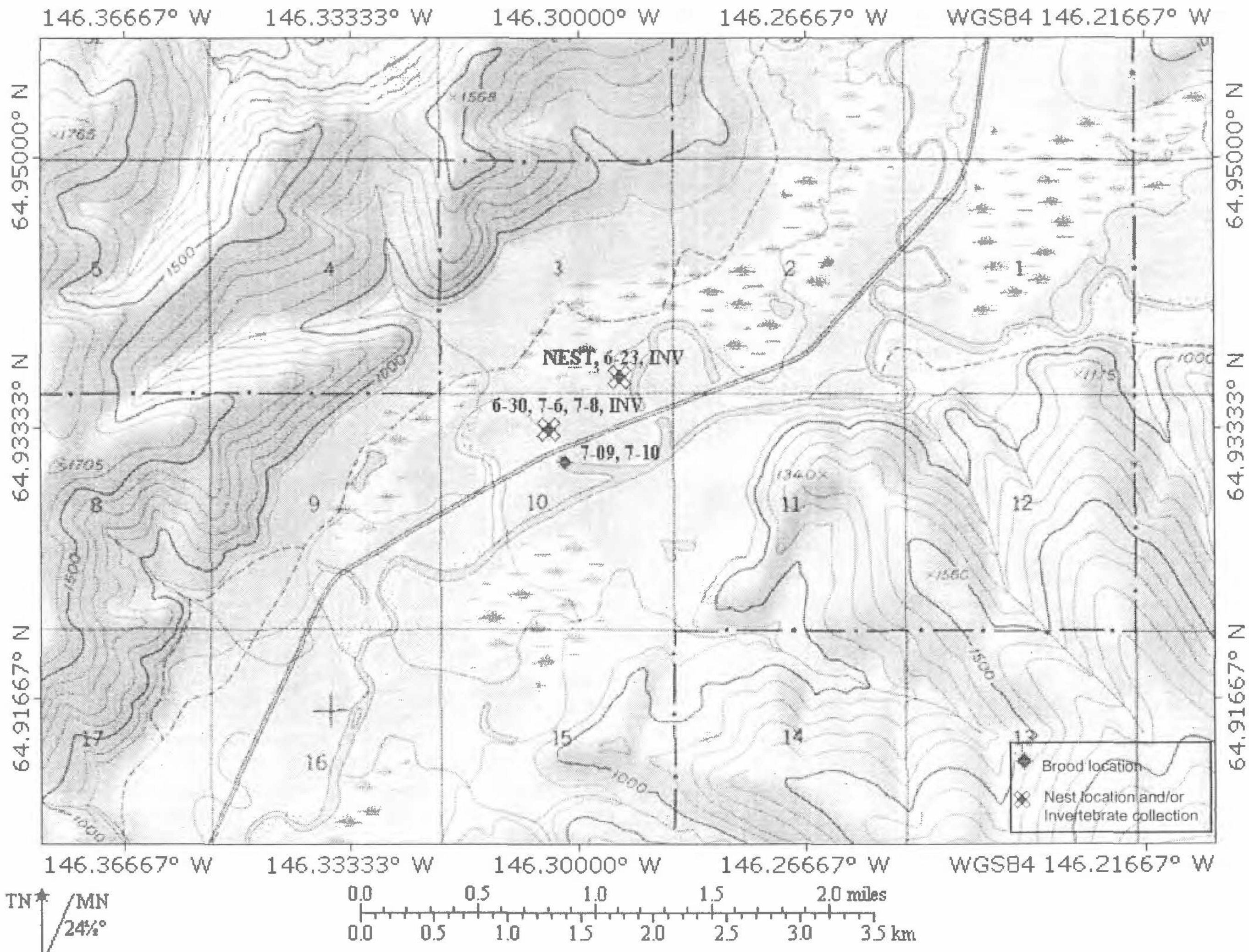


Figure A-12. Locations for brood 97 during the 2002 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

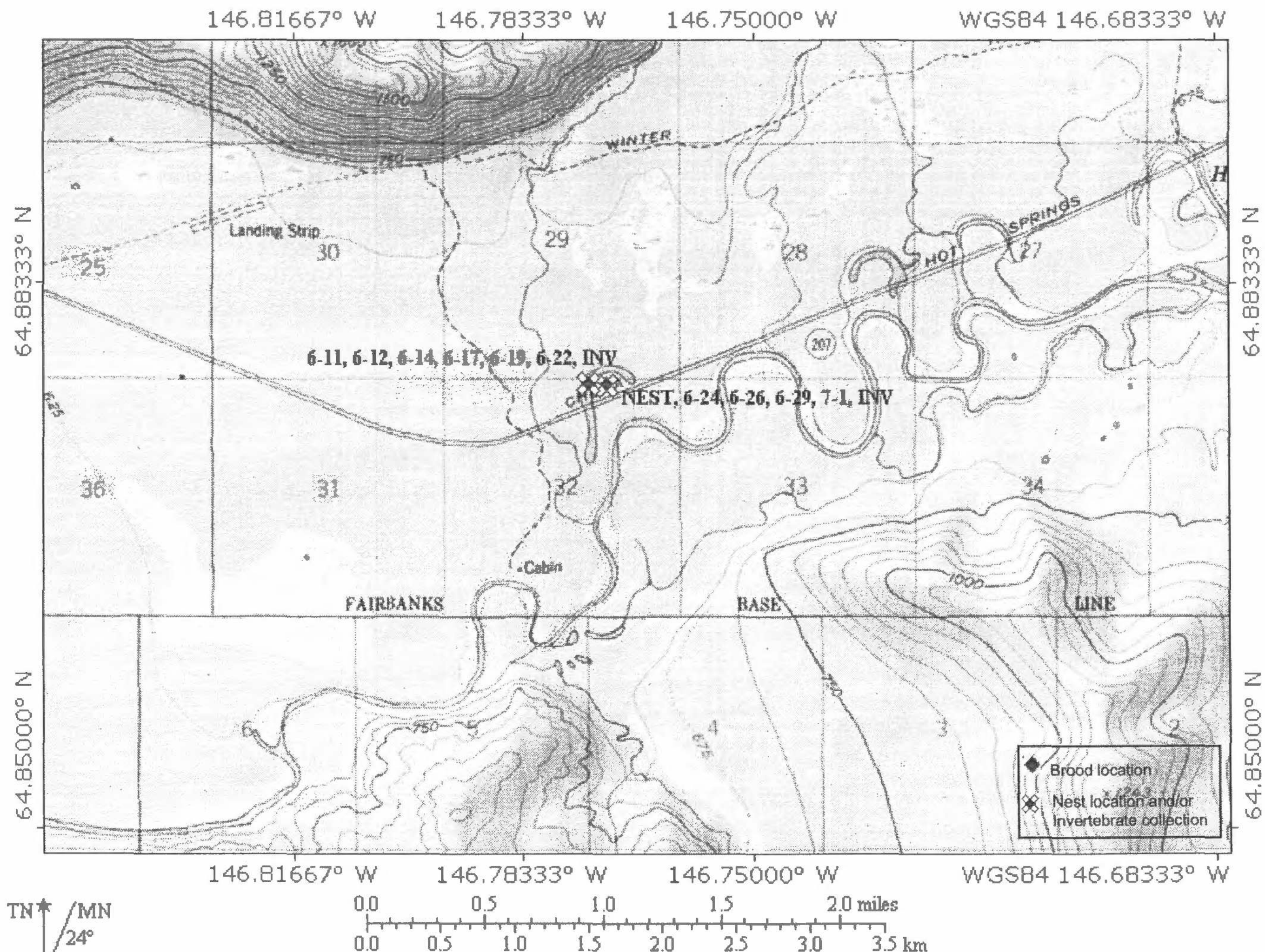


Figure A-13. Locations for brood 111 during the 2002 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

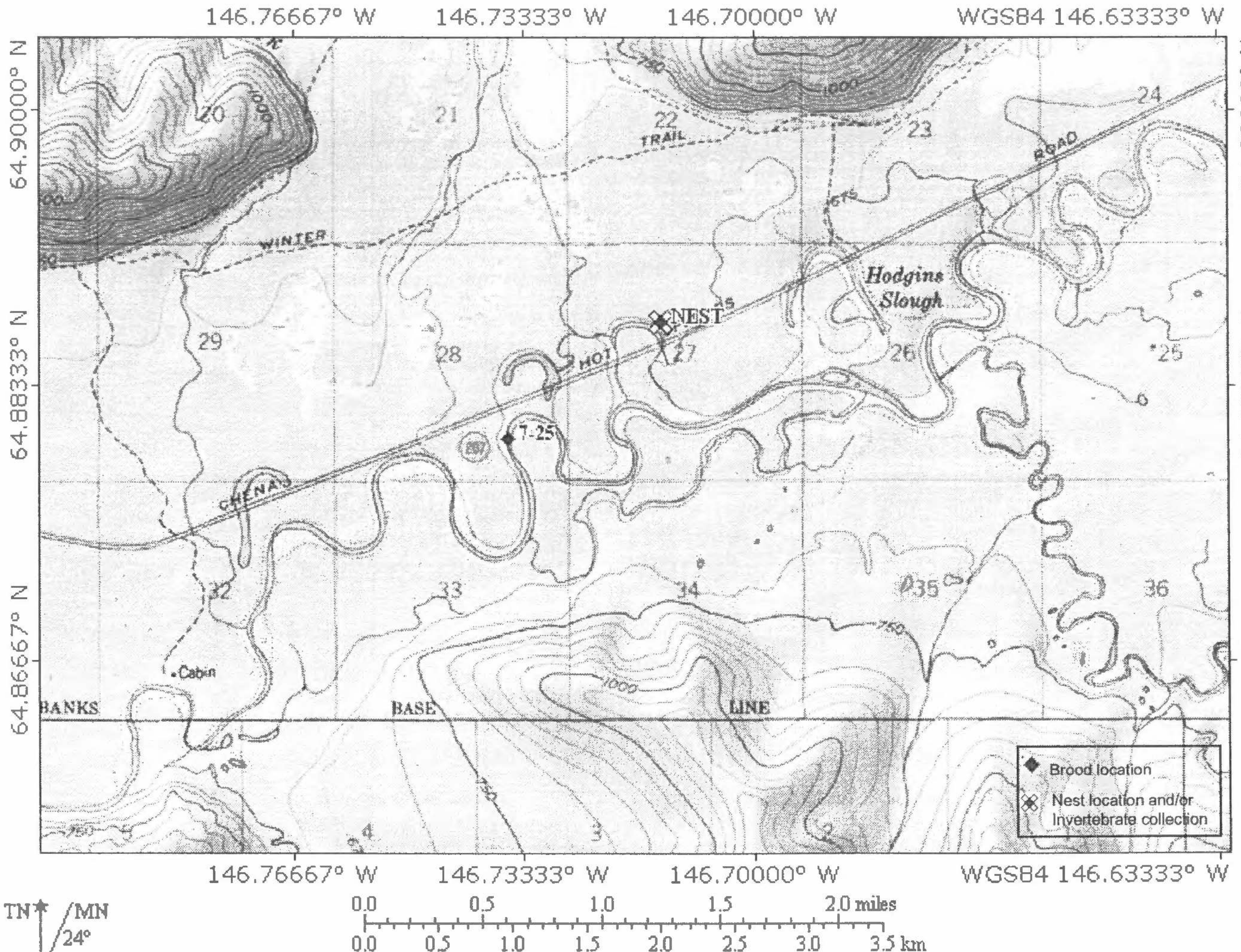


Figure A-14. Locations for brood 114 during the 2002 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

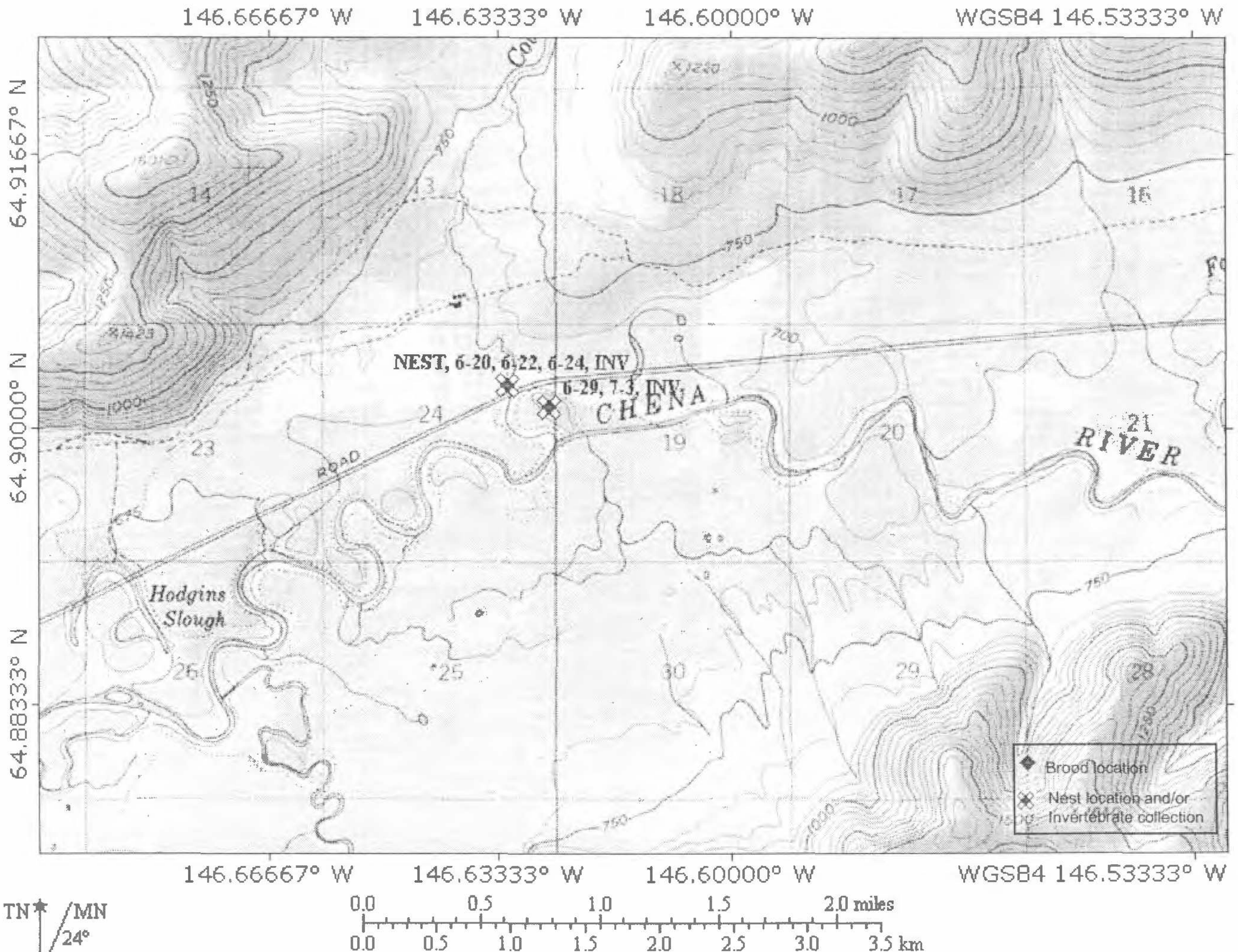


Figure A-15. Locations for brood 125 during the 2002 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

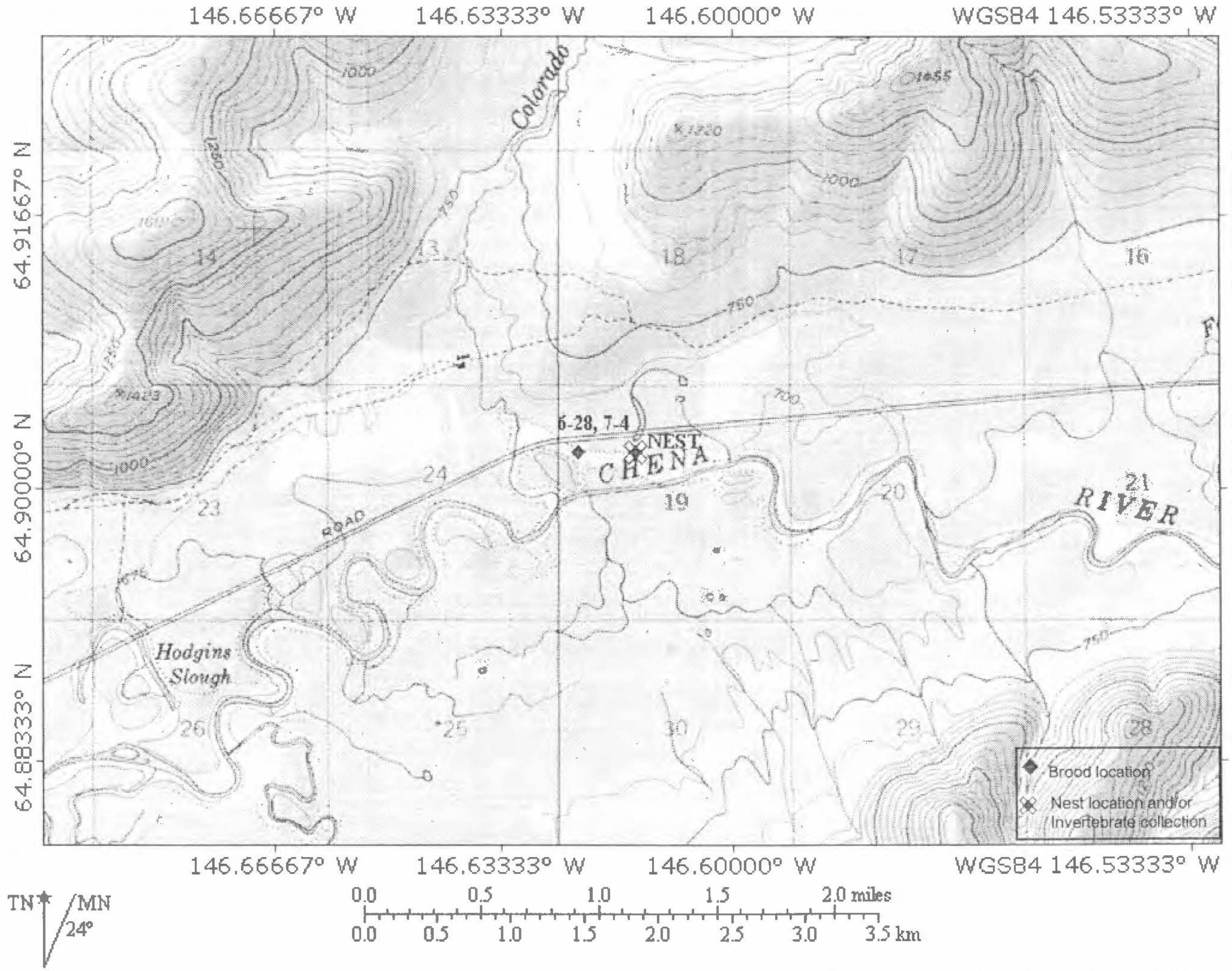


Figure A-16. Locations for brood 136 during the 2002 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

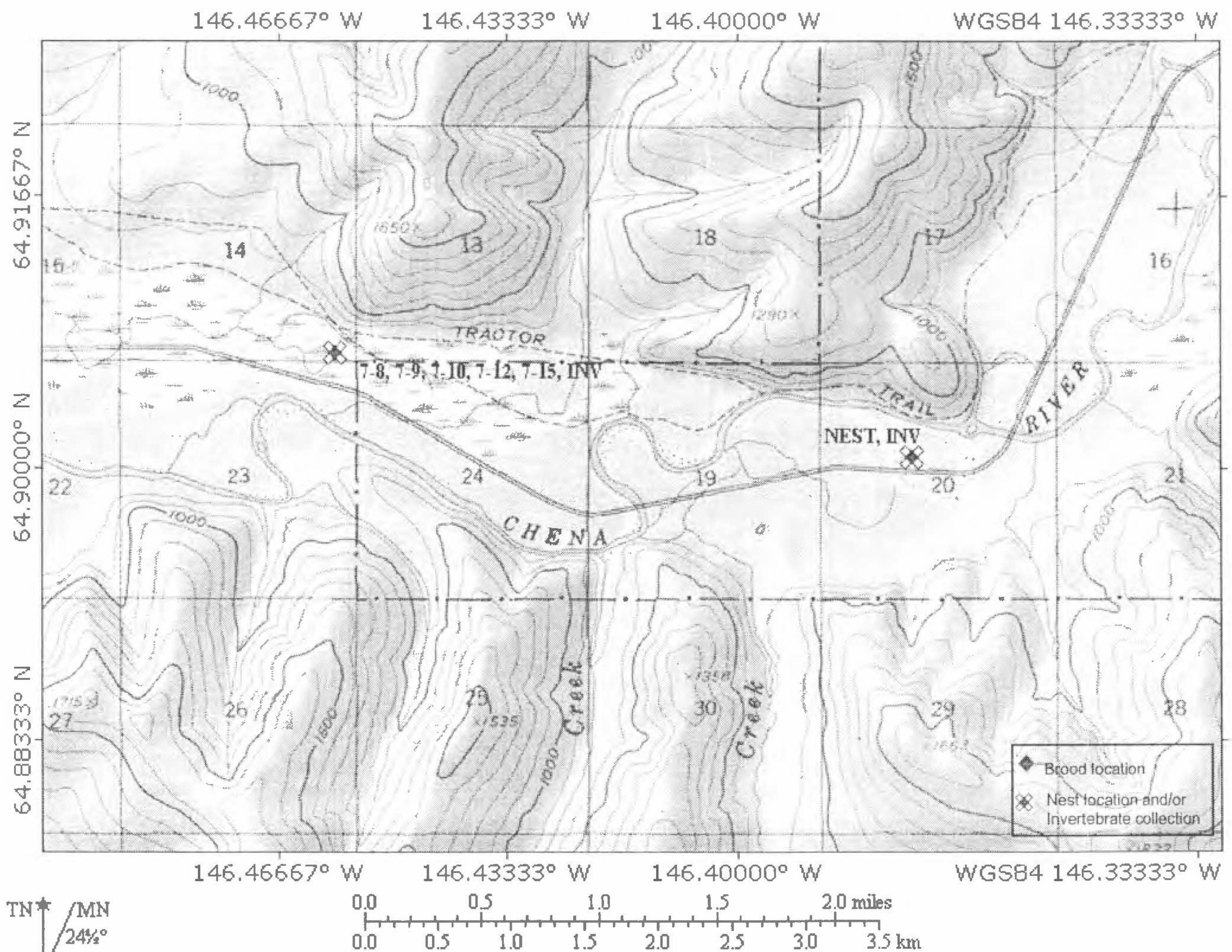


Figure A-17. Locations for brood 138 during the 2002 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

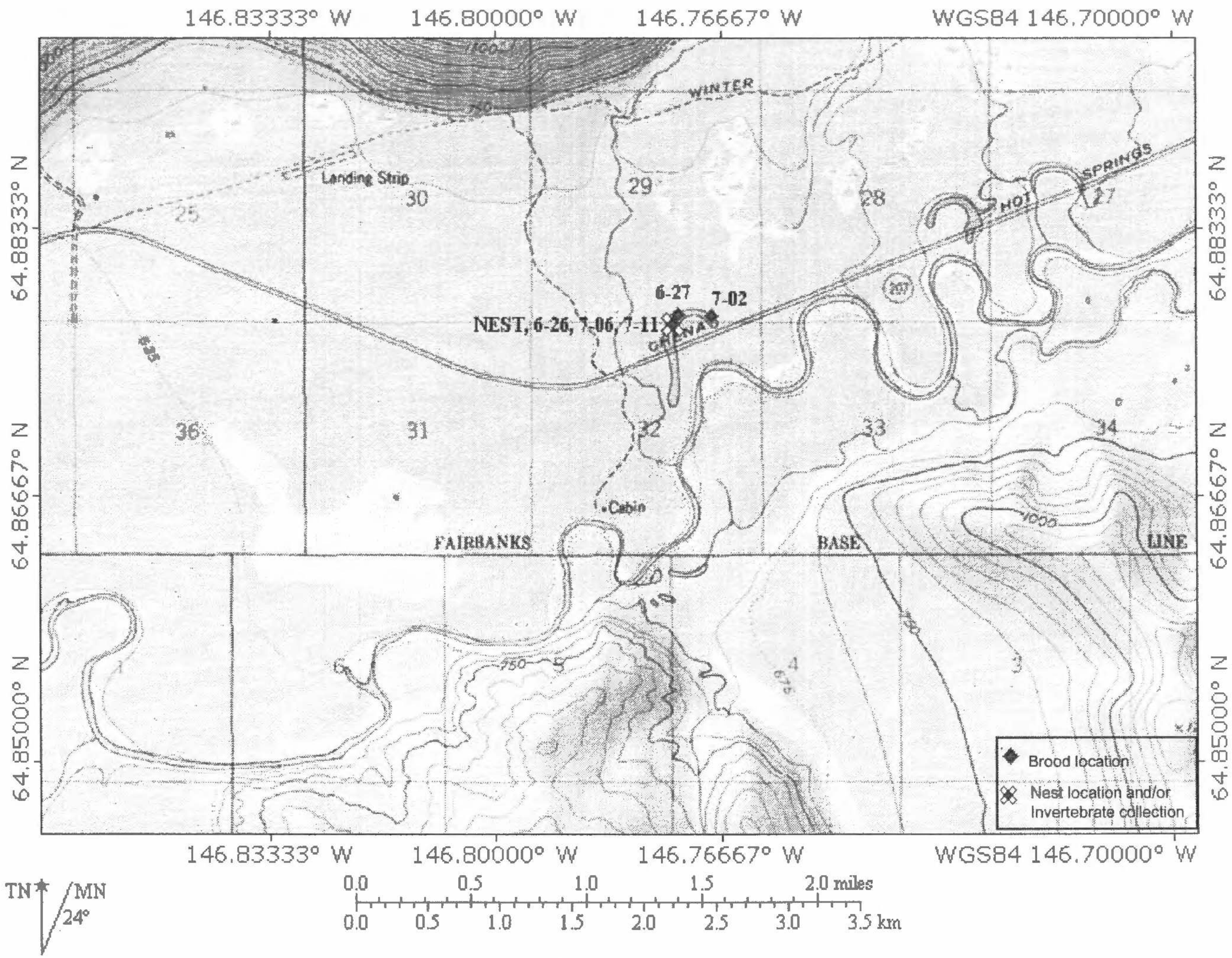


Figure A-18. Locations for brood 3 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

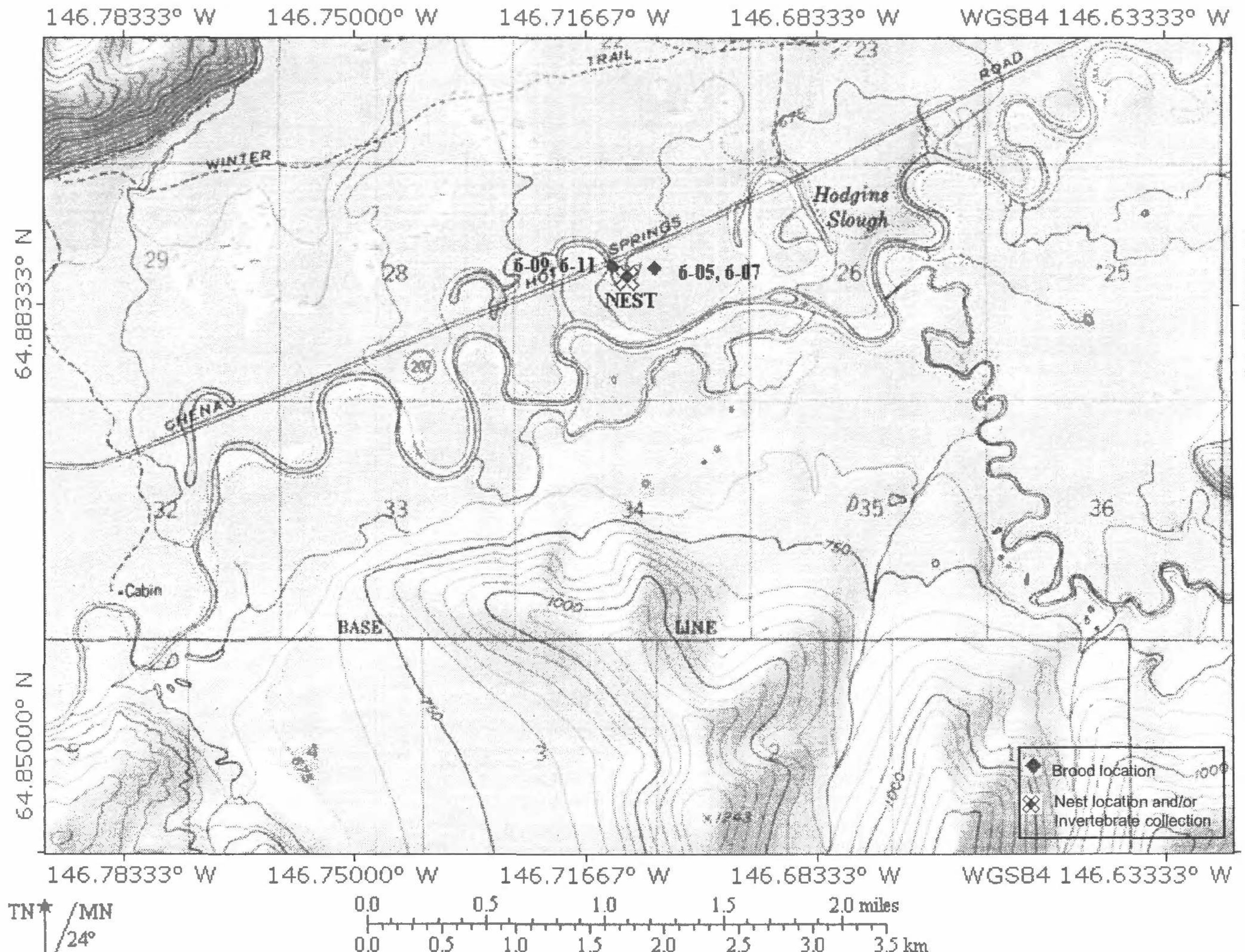


Figure A-19. Locations for brood 13 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

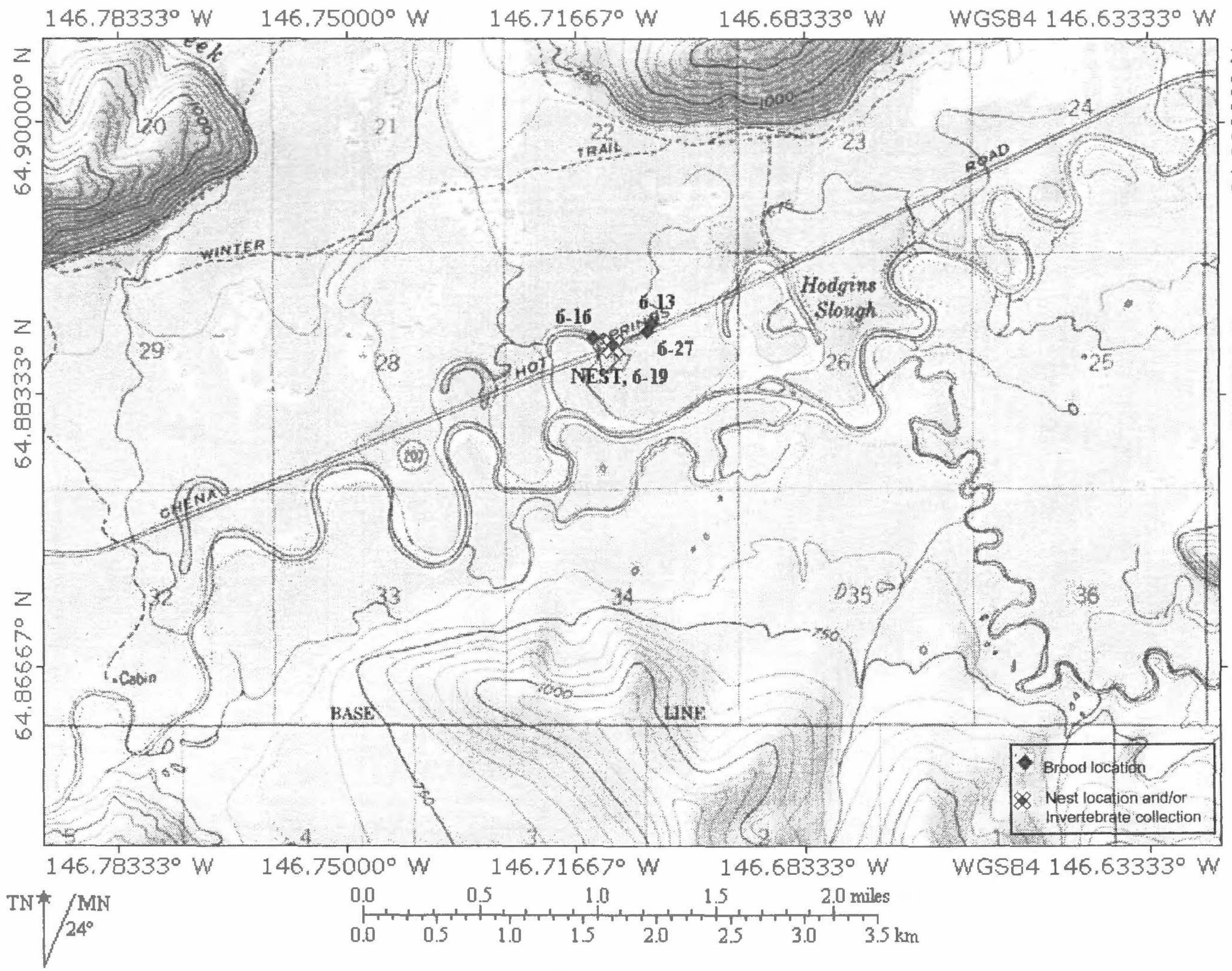


Figure A-20. Locations for brood 14 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

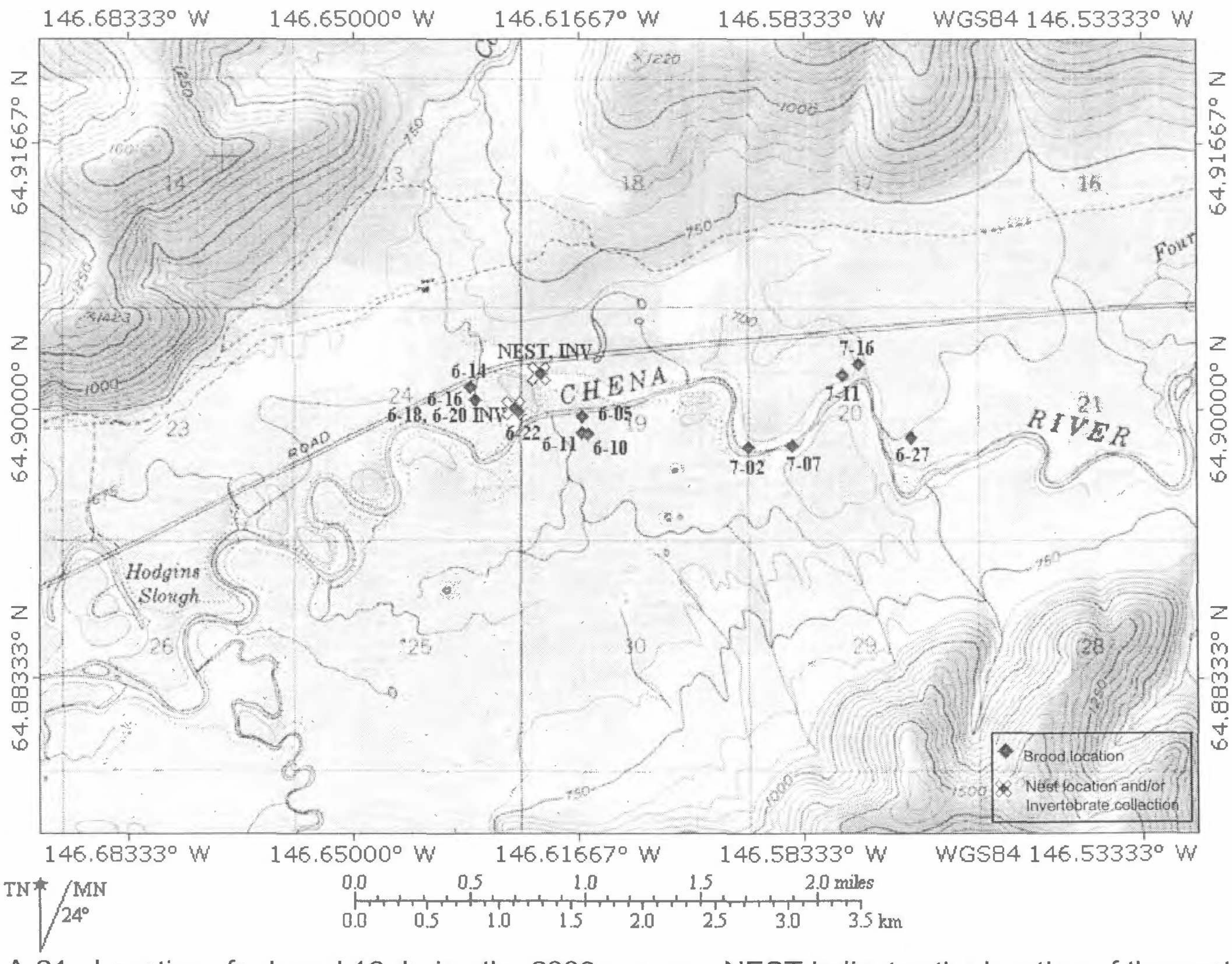


Figure A-21. Locations for brood 16 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

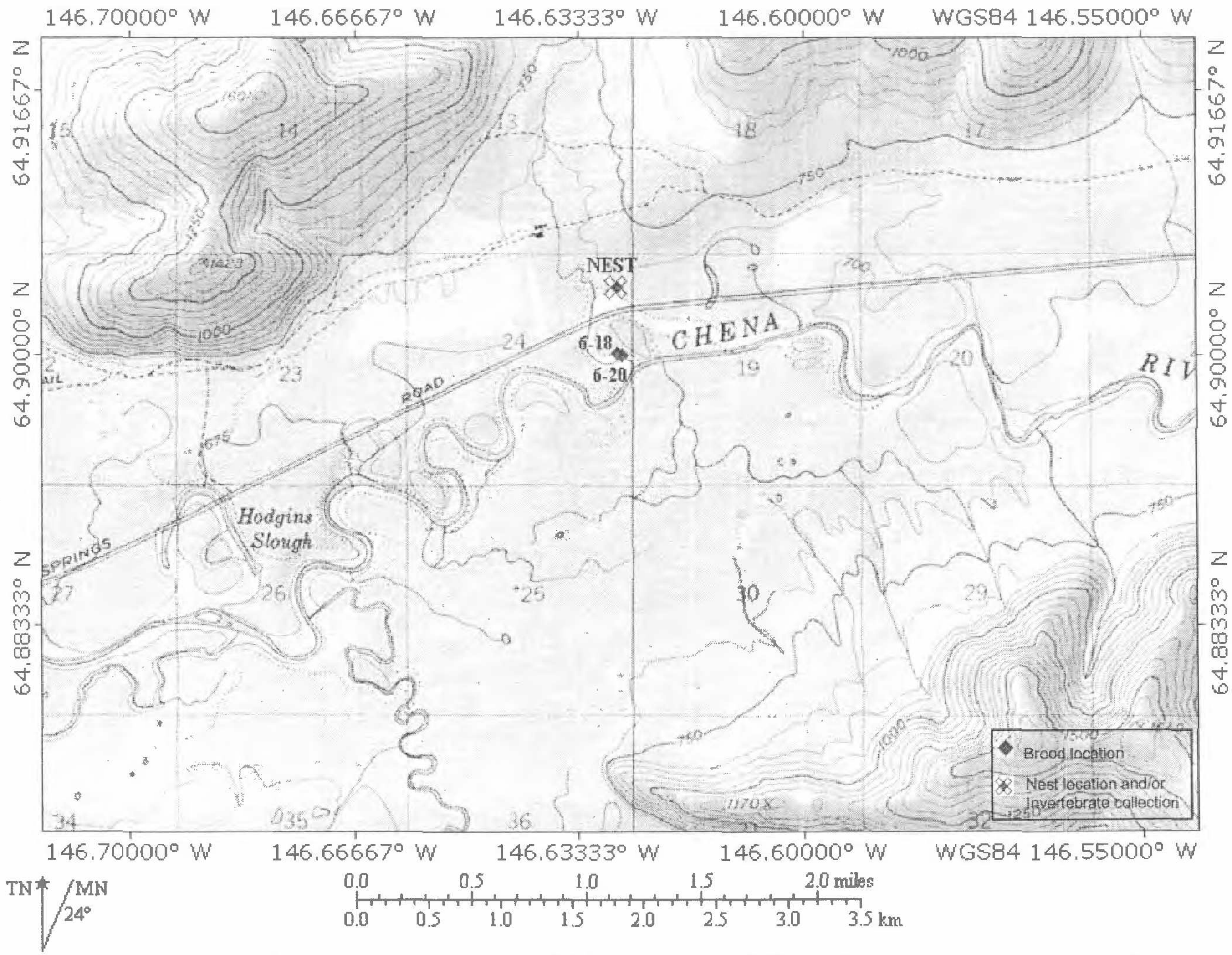


Figure A-22. Locations for brood 19 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

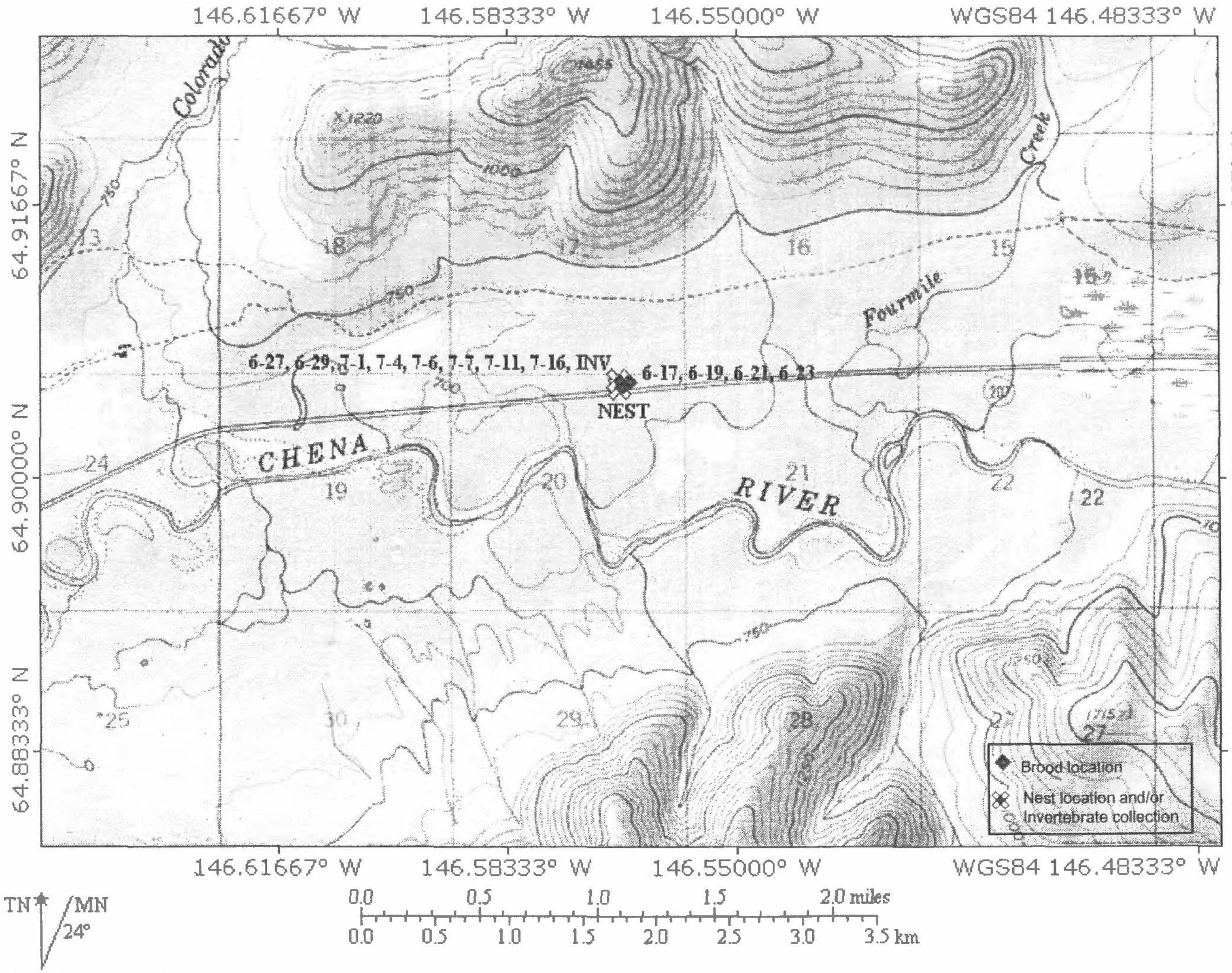


Figure A-23. Locations for brood 22 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

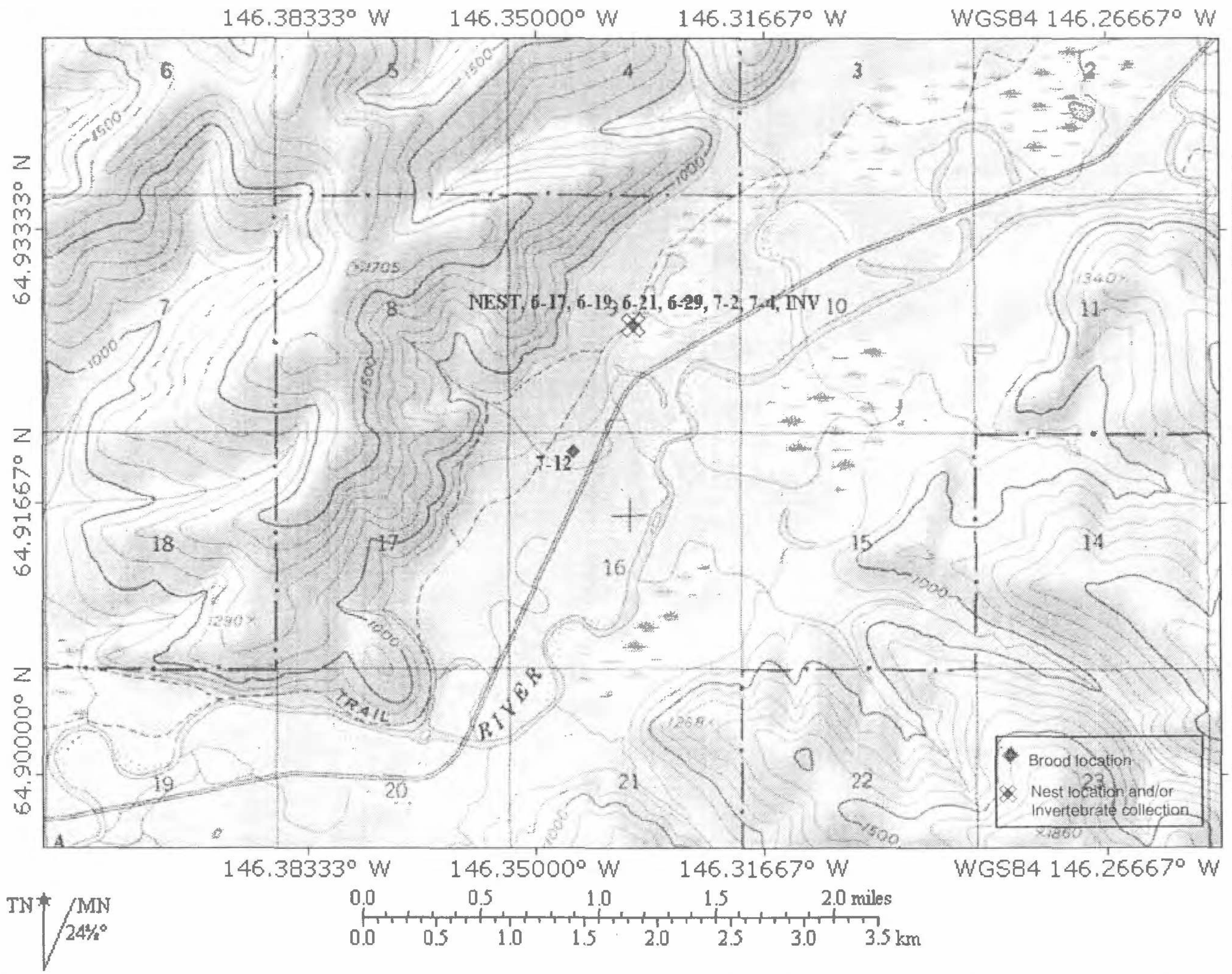


Figure A-24. Locations for brood 39 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

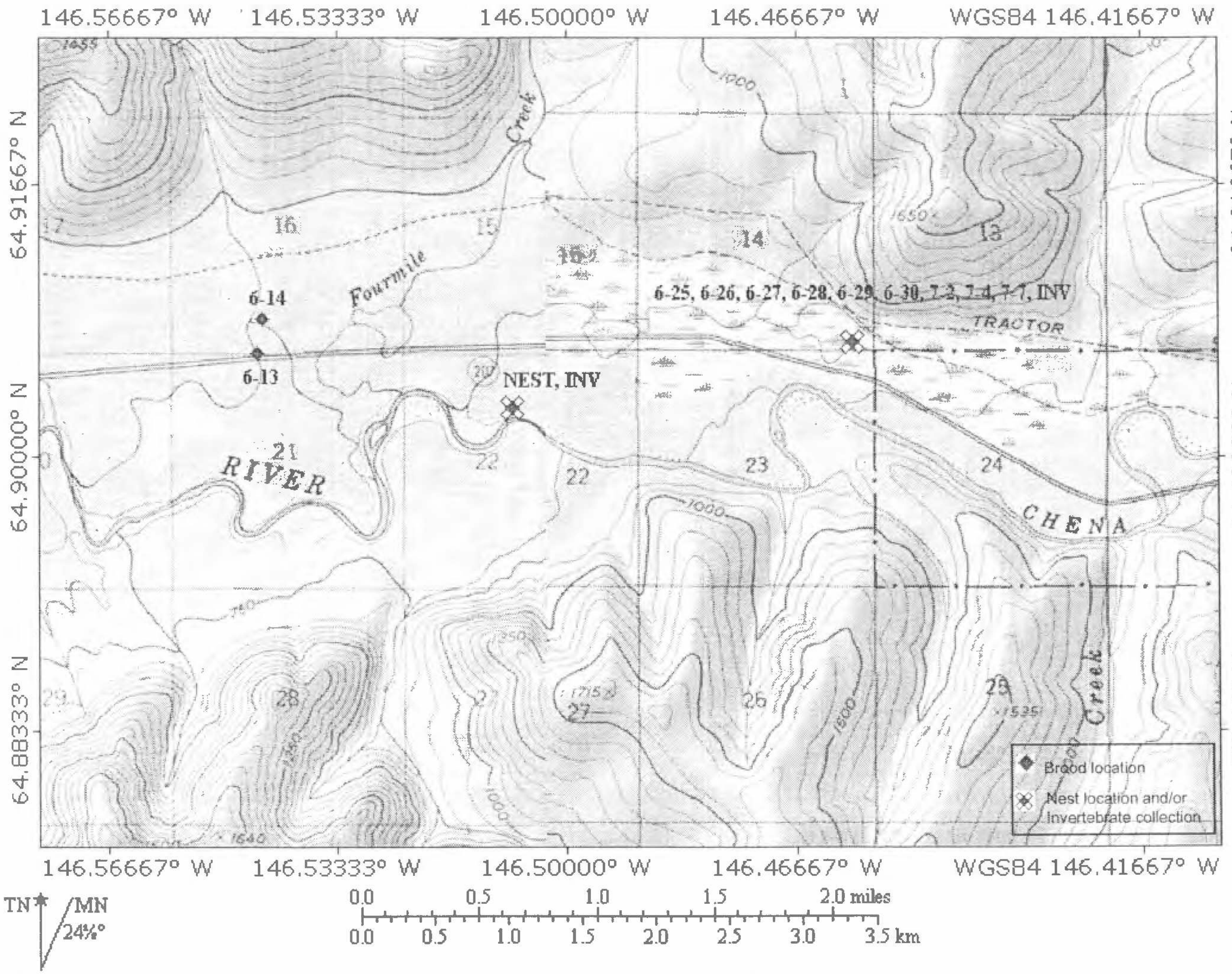


Figure A-25. Locations for brood 41 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

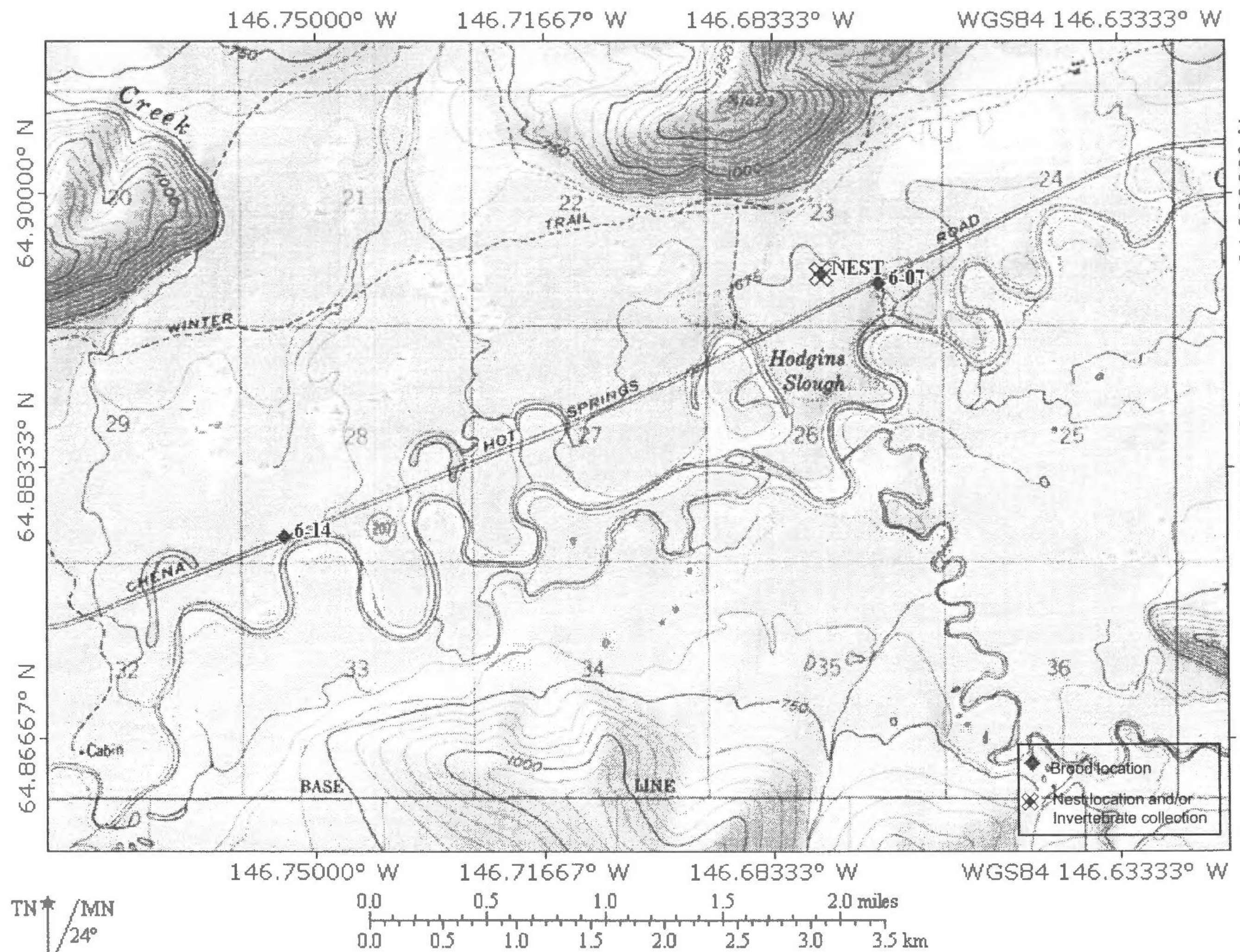


Figure A-26. Locations for brood 43 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

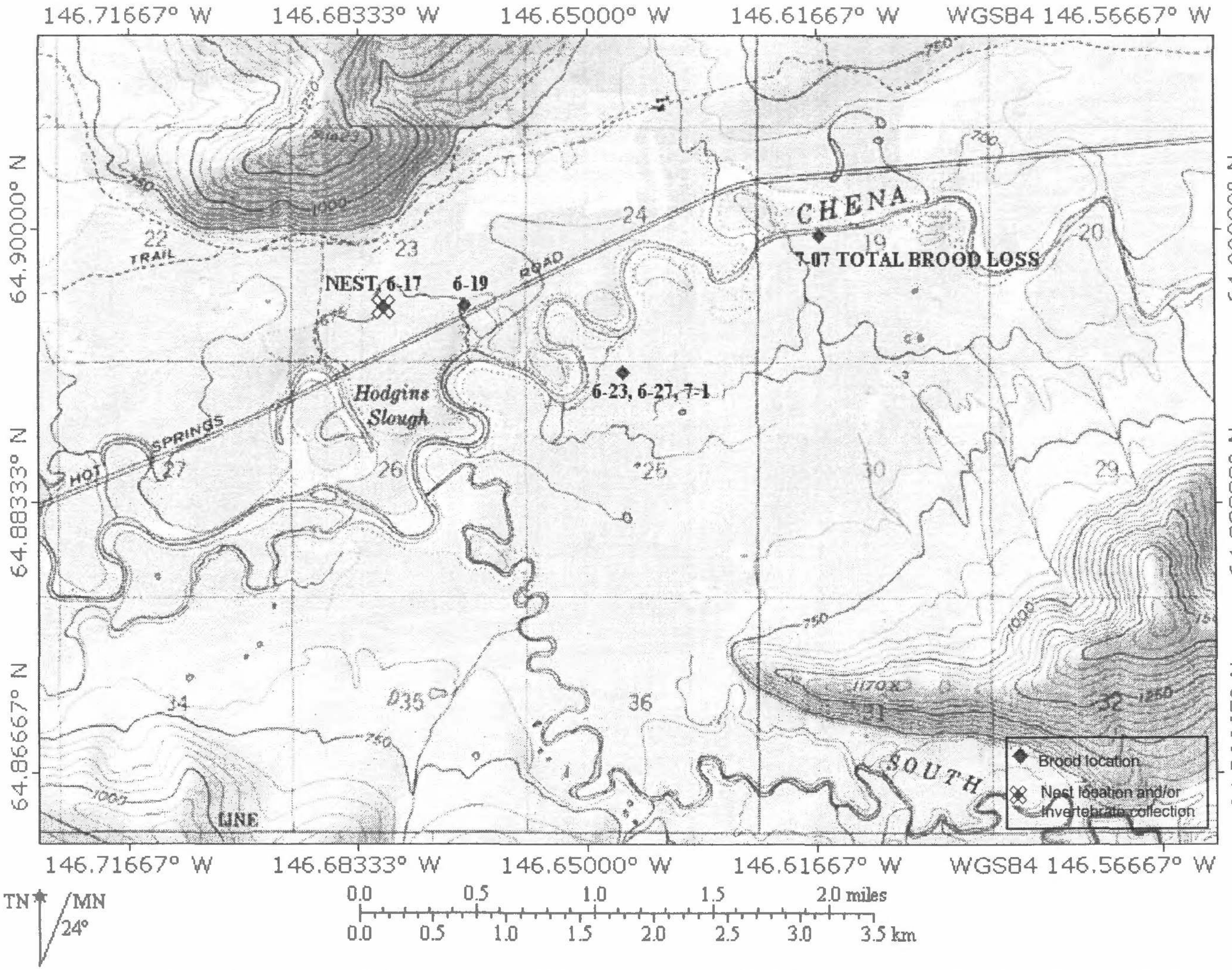


Figure A-27. Locations for brood 44 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

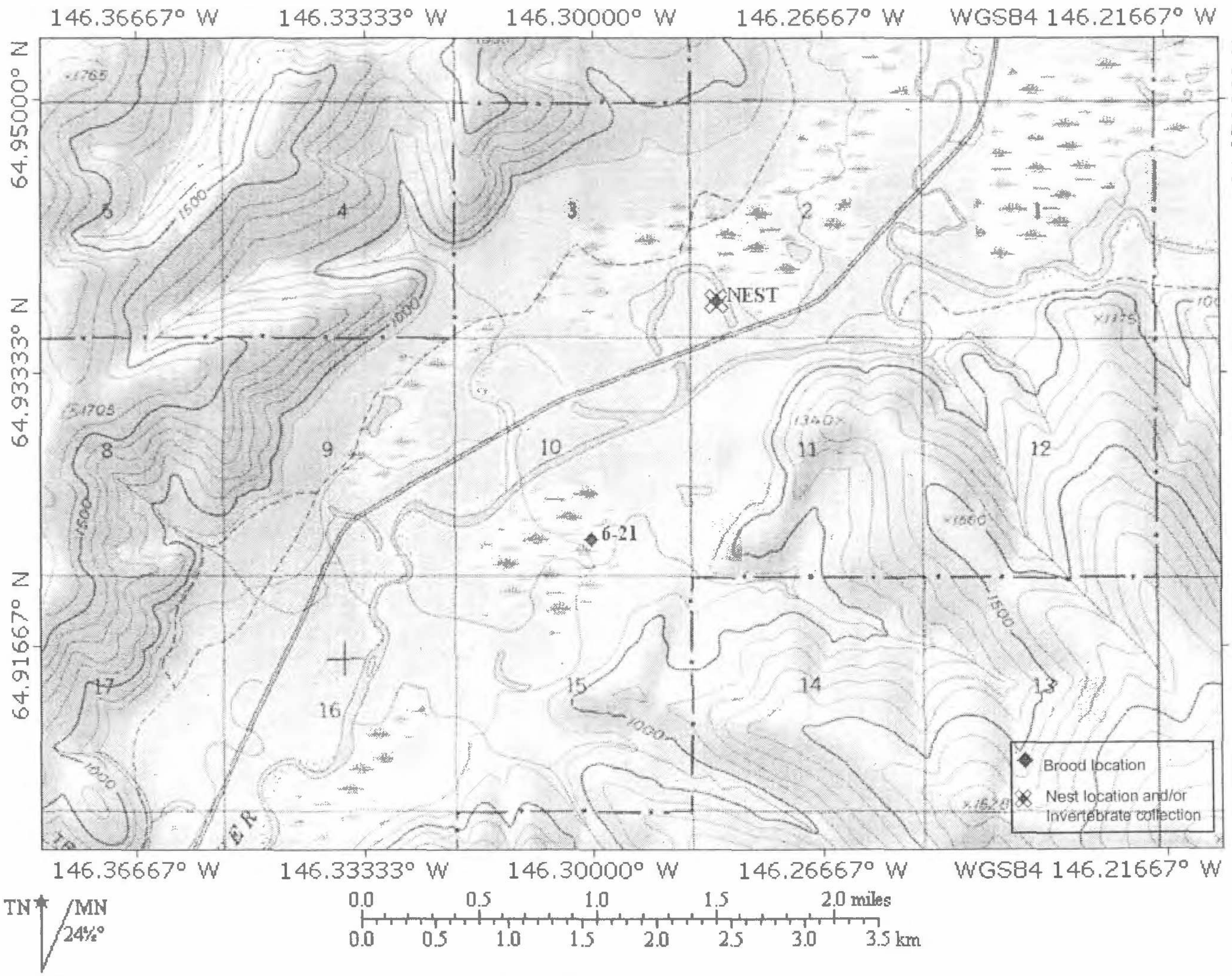


Figure A-28. Locations for brood 45 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

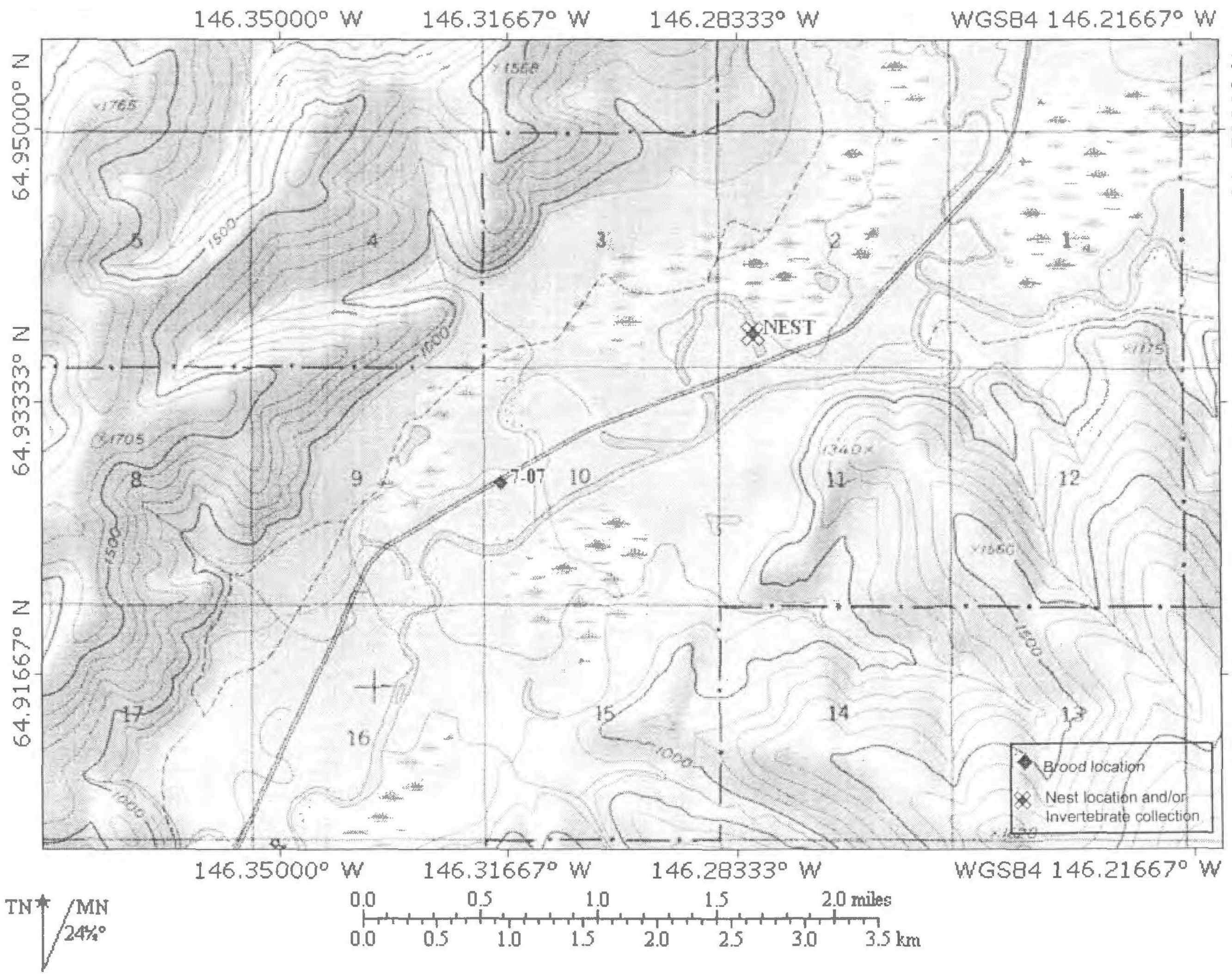


Figure A-29. Locations for brood 47 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

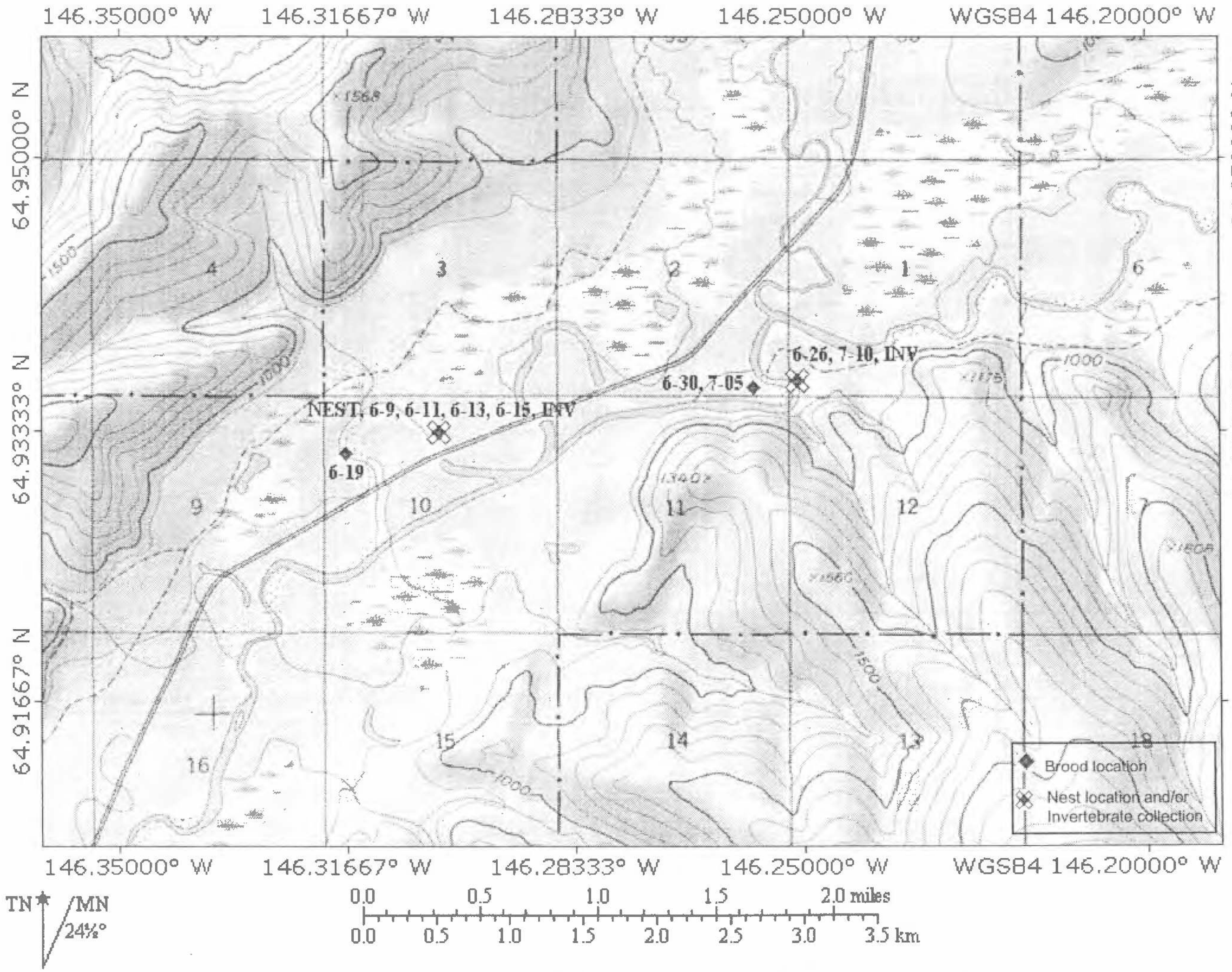


Figure A-30. Locations for brood 51 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

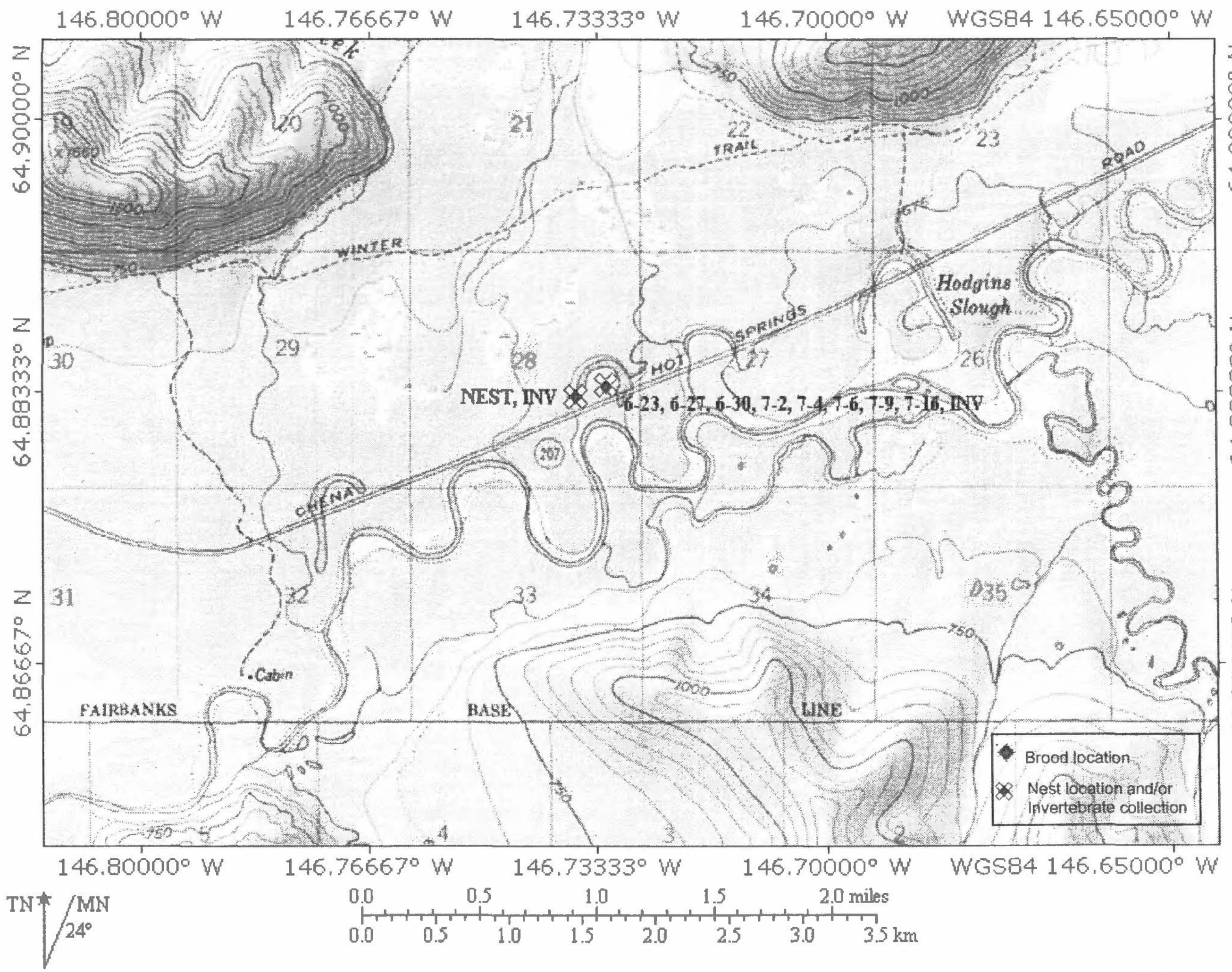


Figure A-31. Locations for brood 53 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

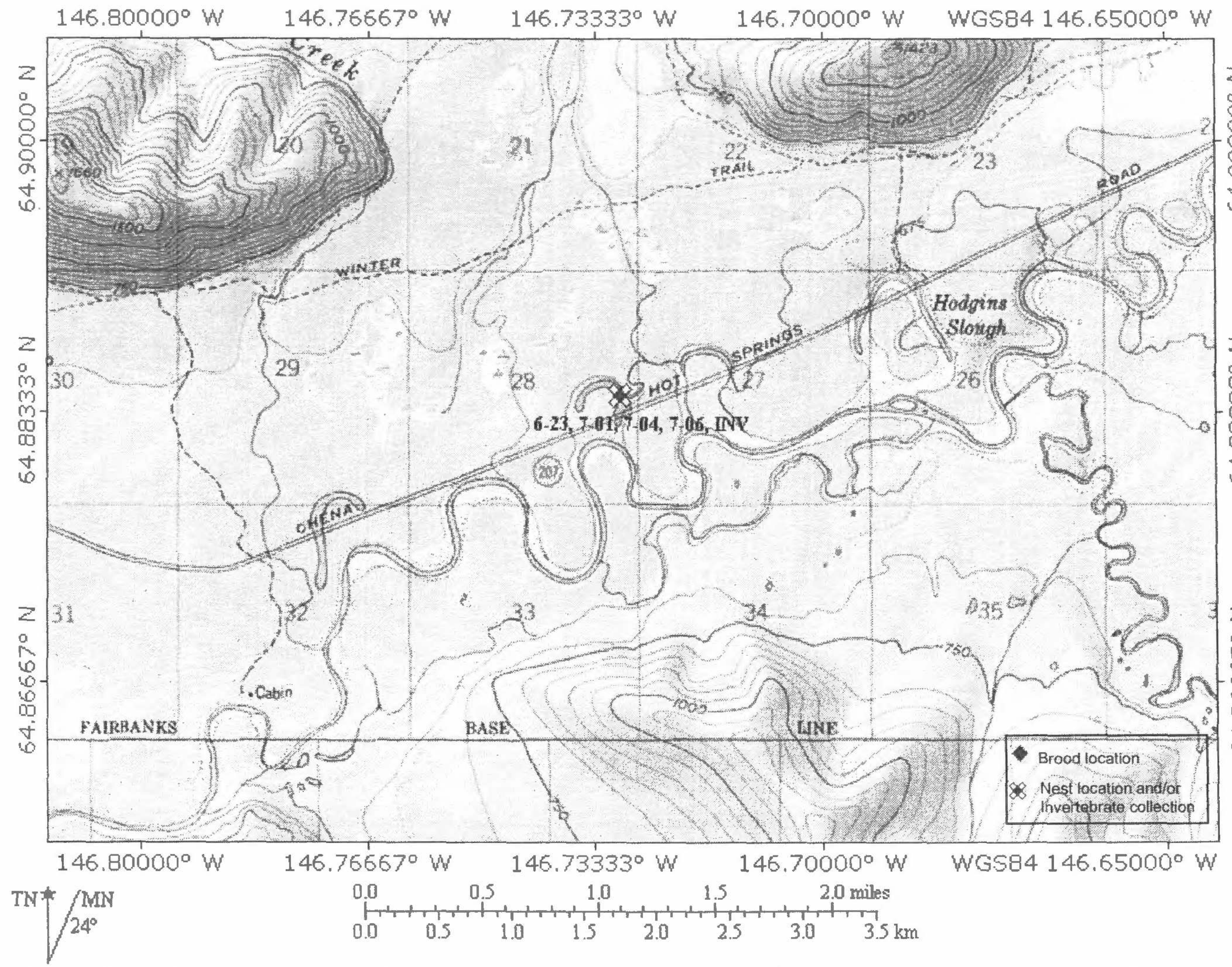


Figure A-32. Locations for brood 56 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

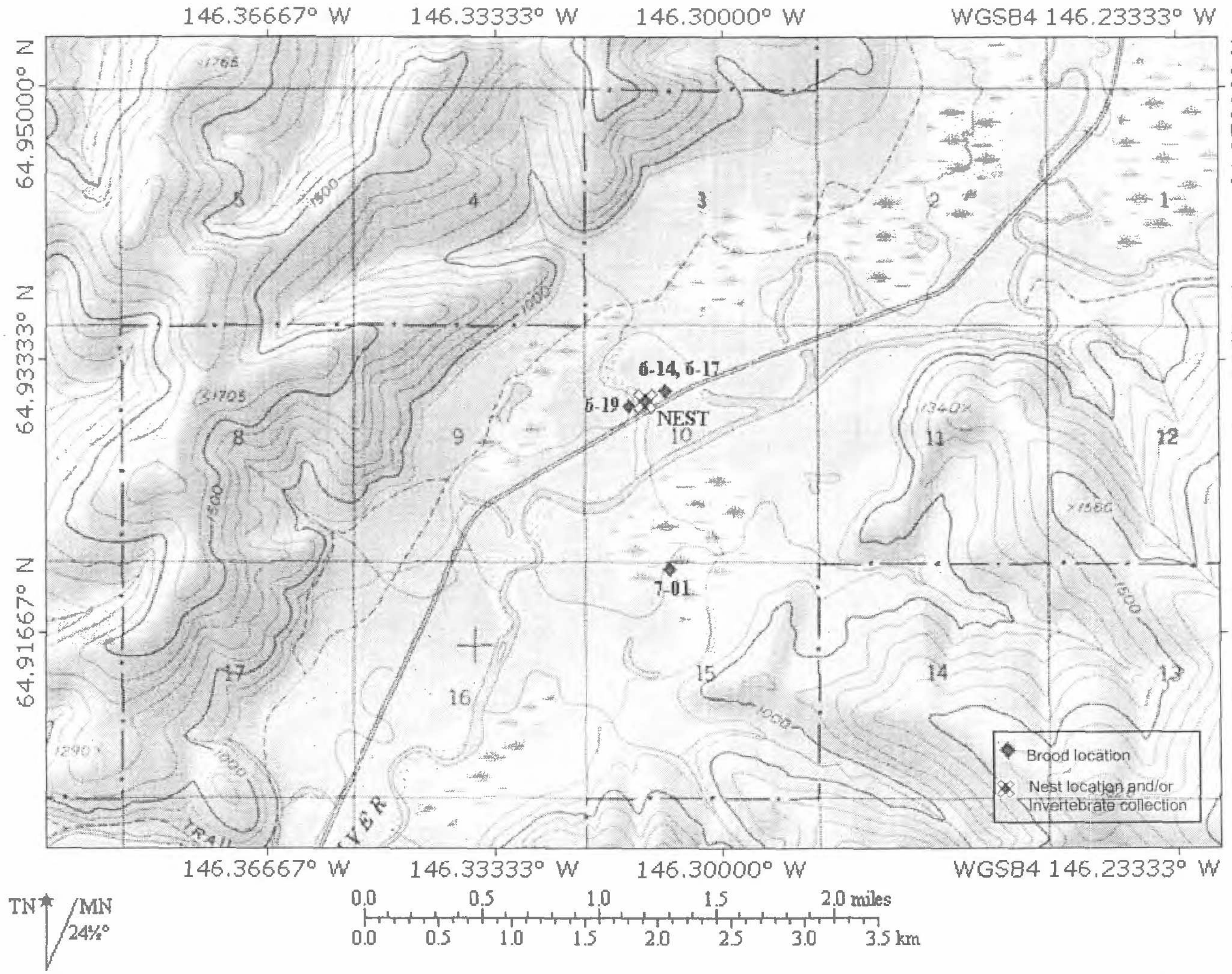


Figure A-33. Locations for brood 69 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

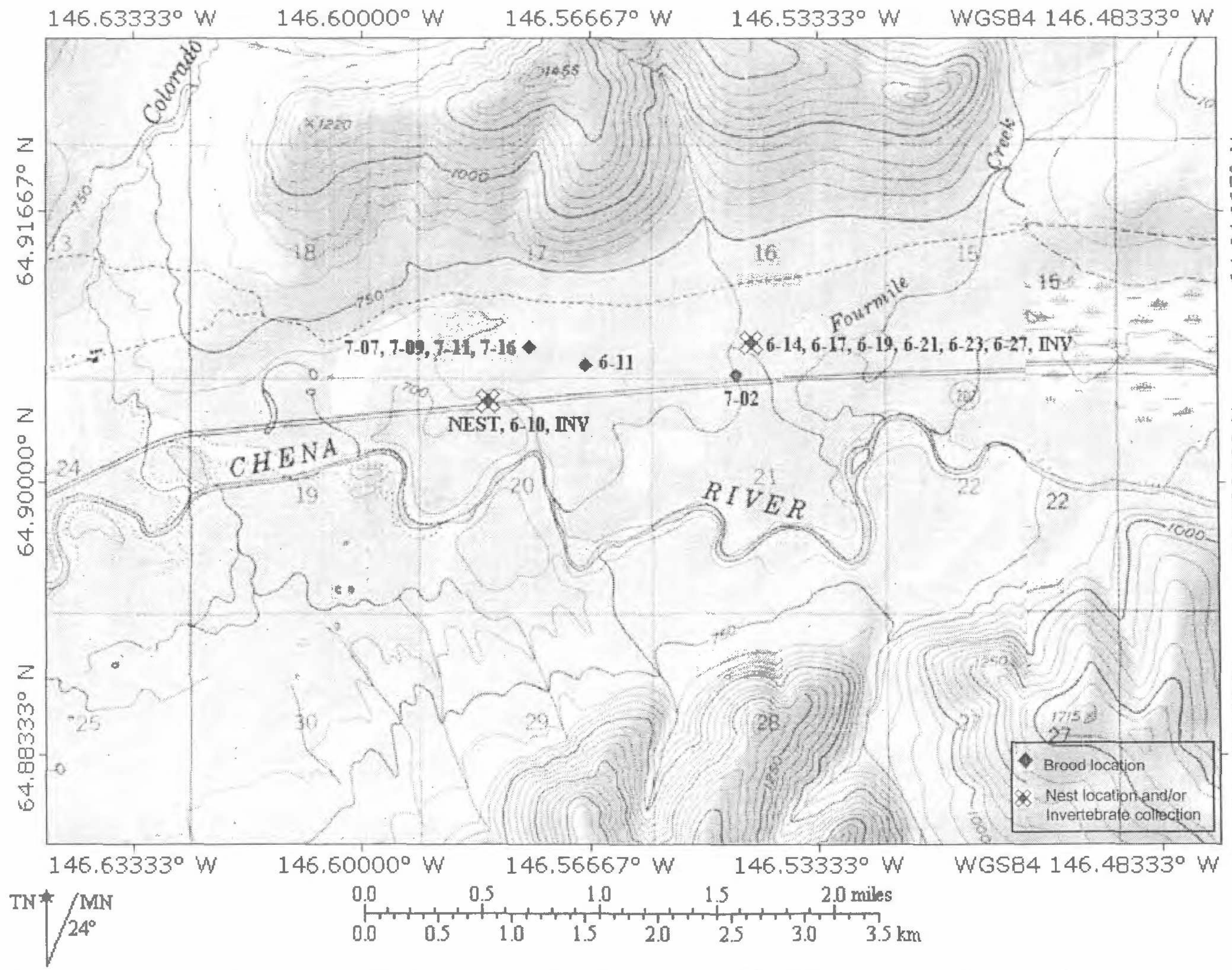


Figure A-34. Locations for brood 72 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

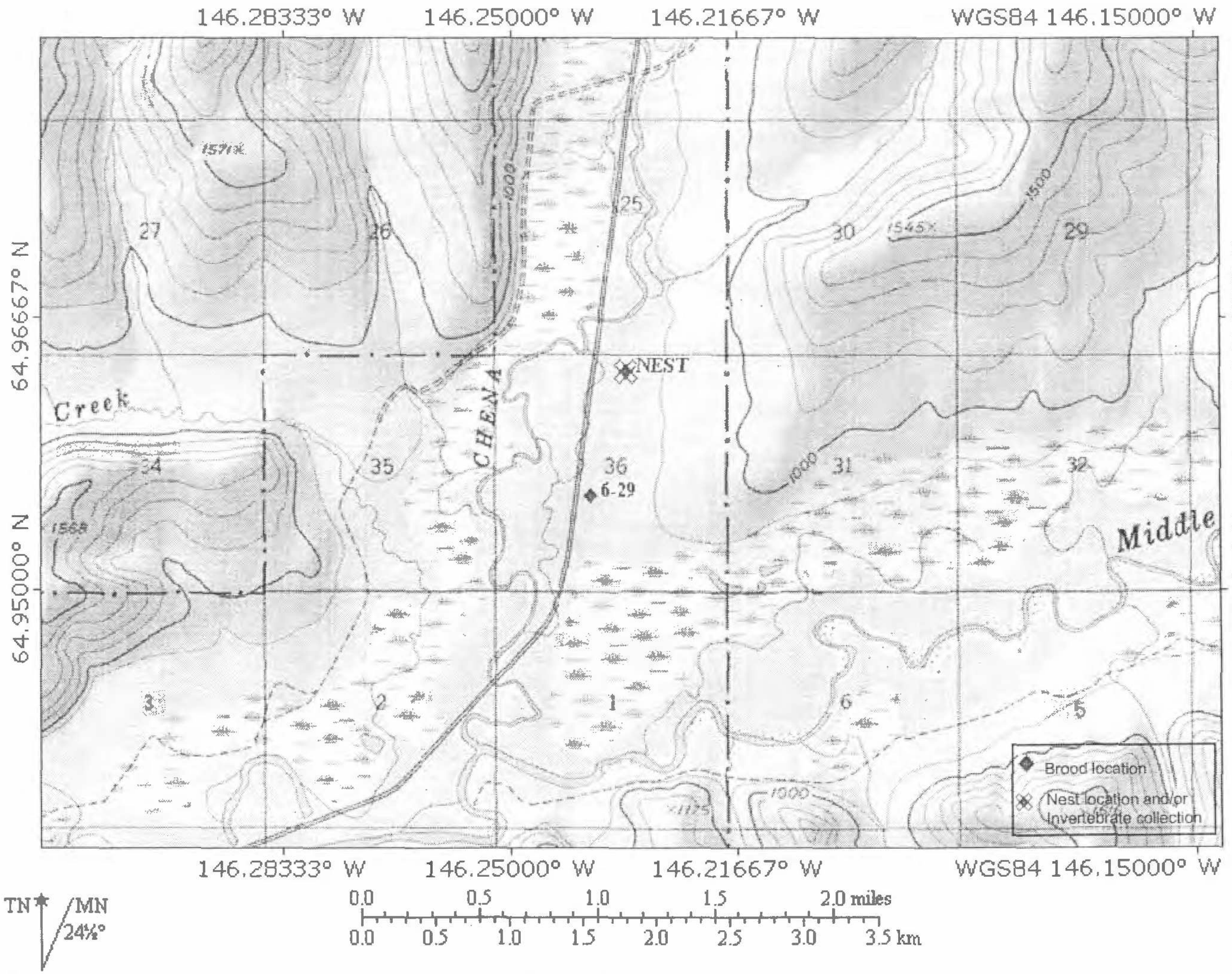


Figure A-35. Locations for brood 83 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

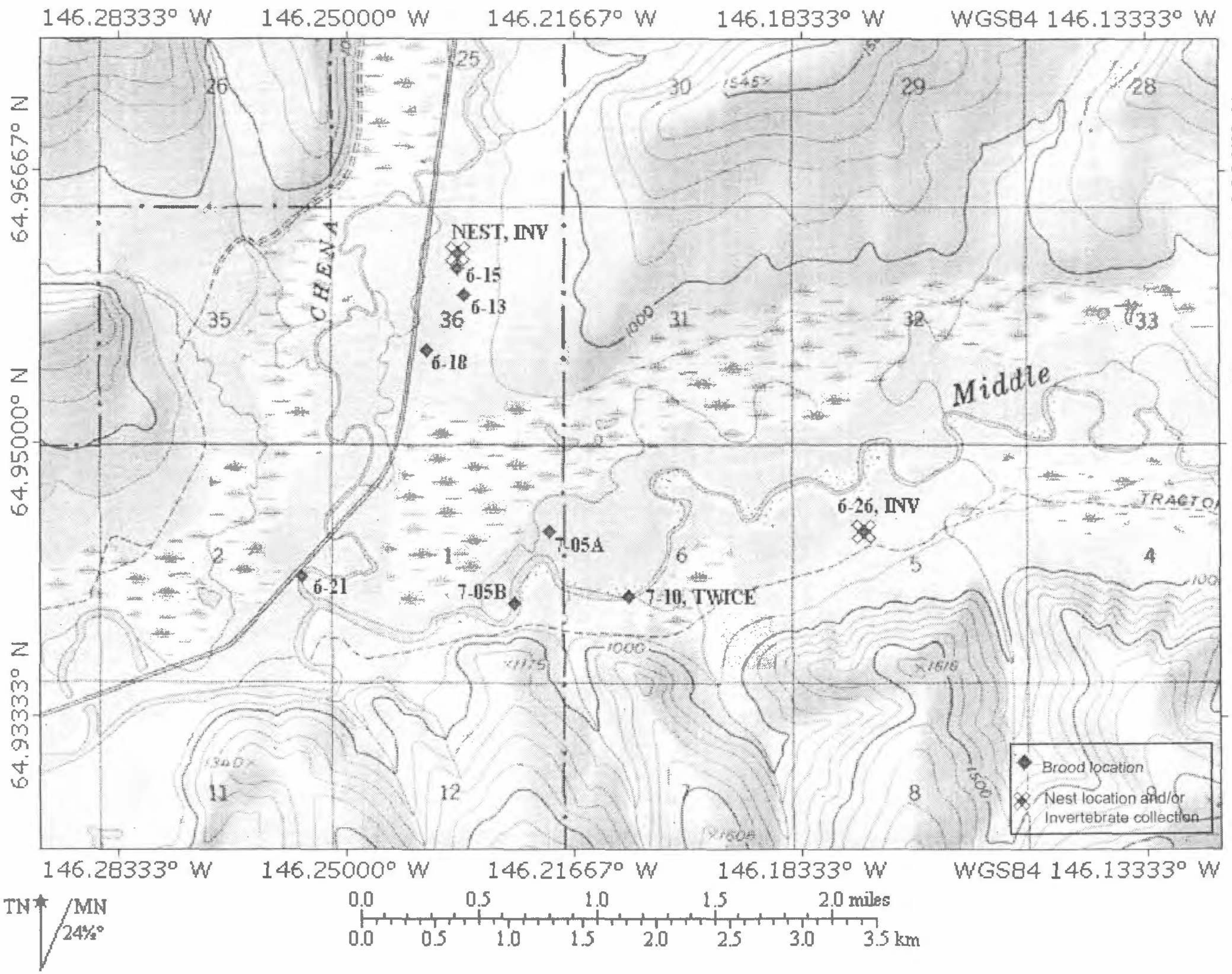


Figure A-36. Locations for brood 84 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

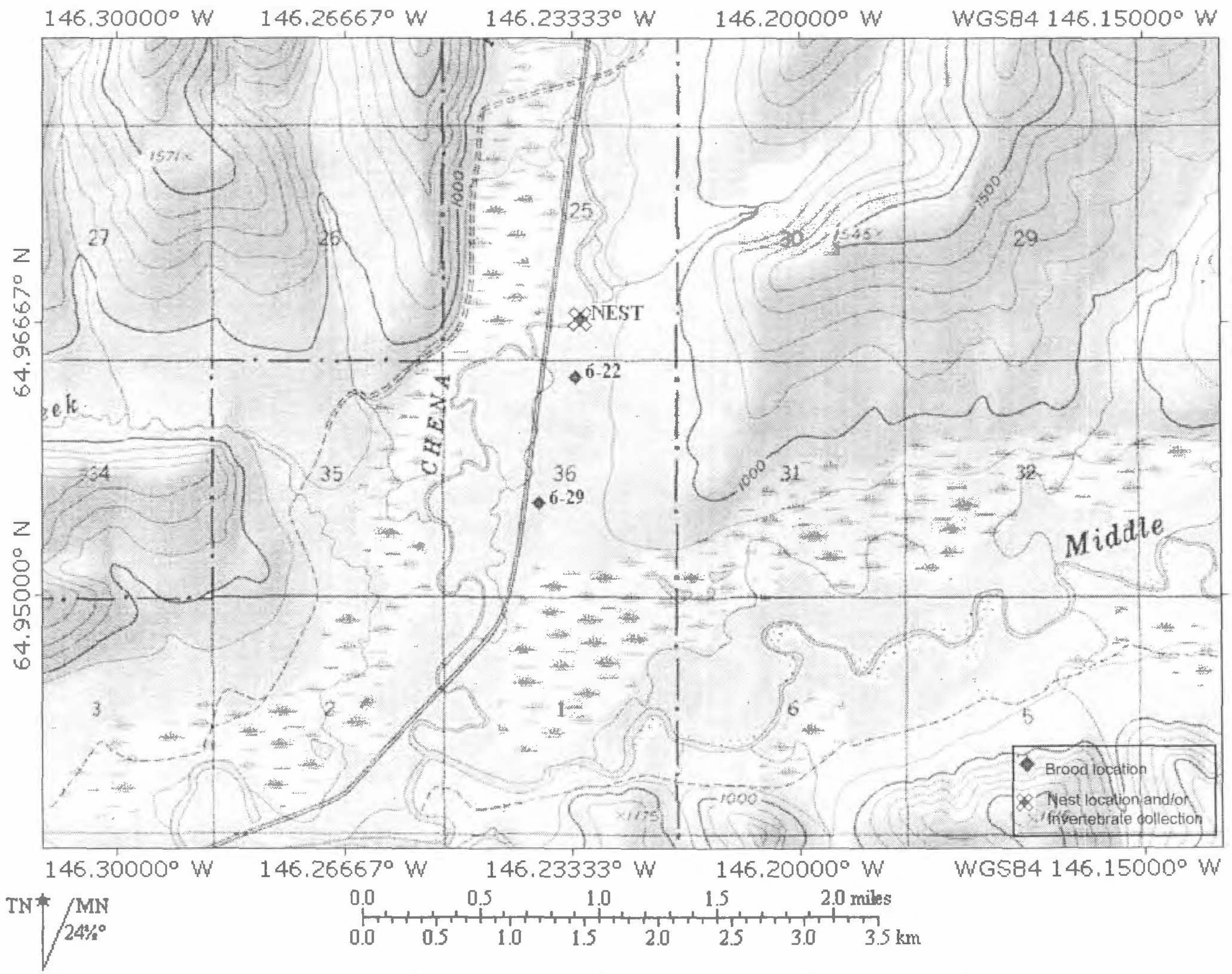


Figure A-37. Locations for brood 89 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

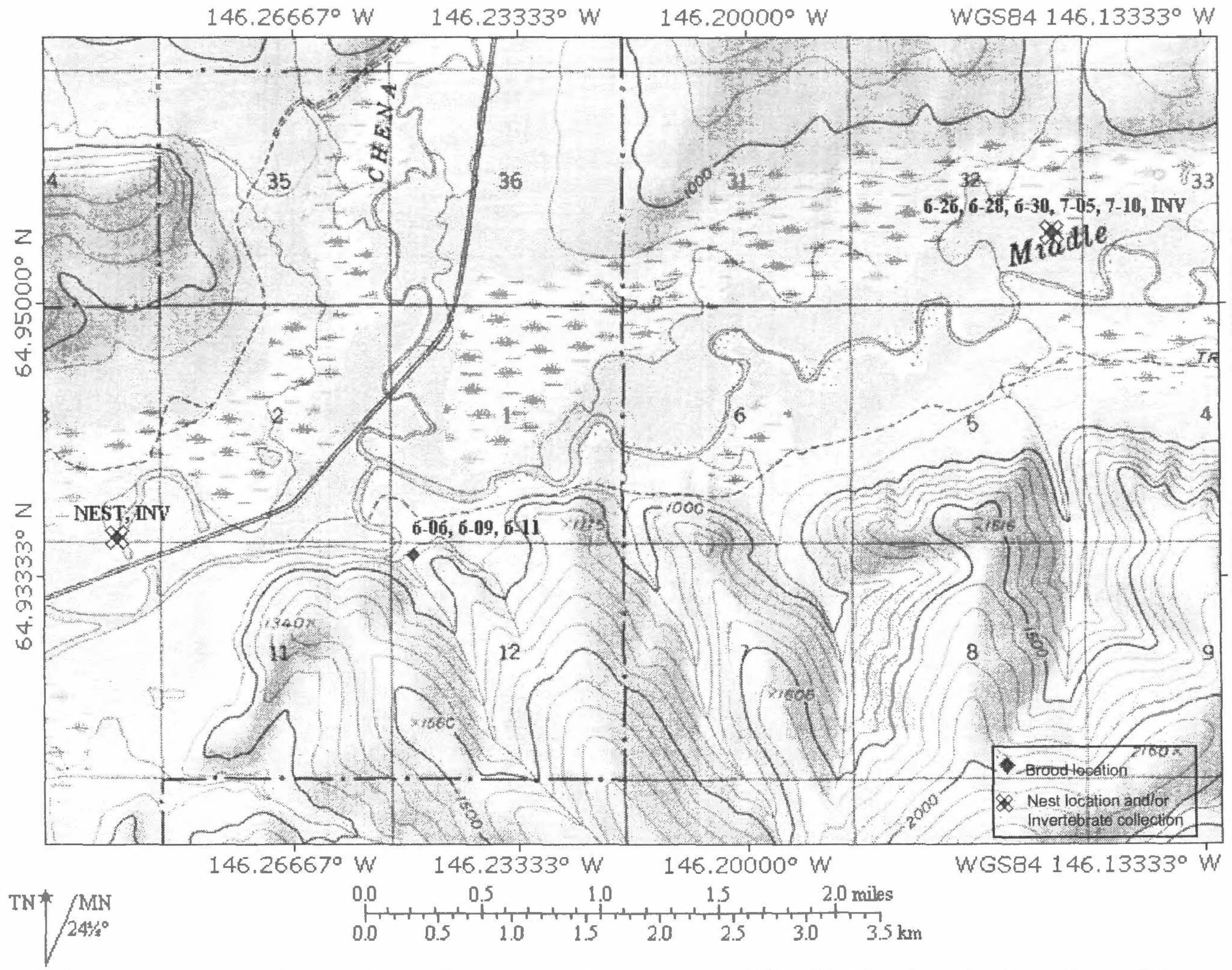


Figure A-38. Locations for brood 96 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

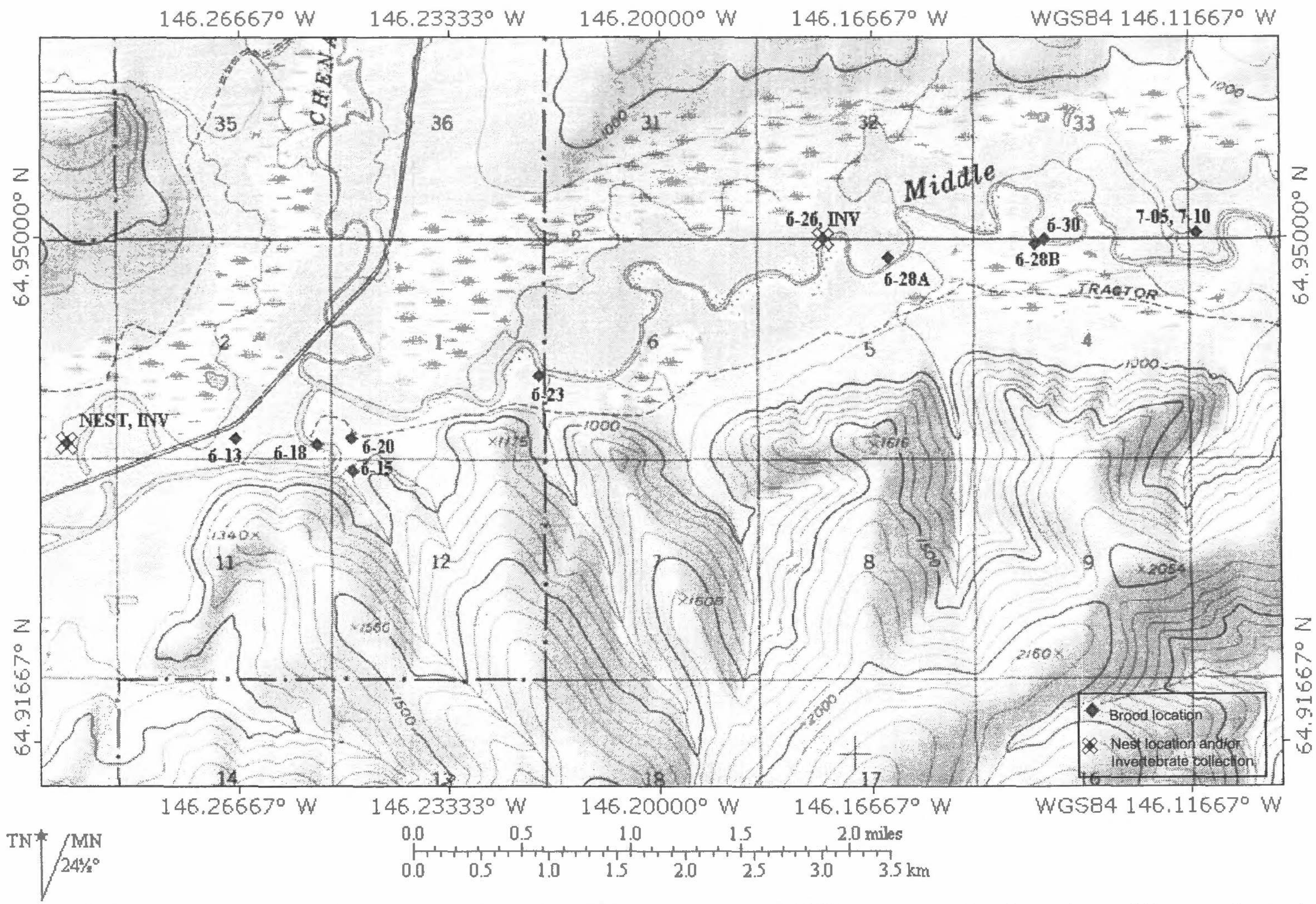


Figure A-39. Locations for brood 97 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

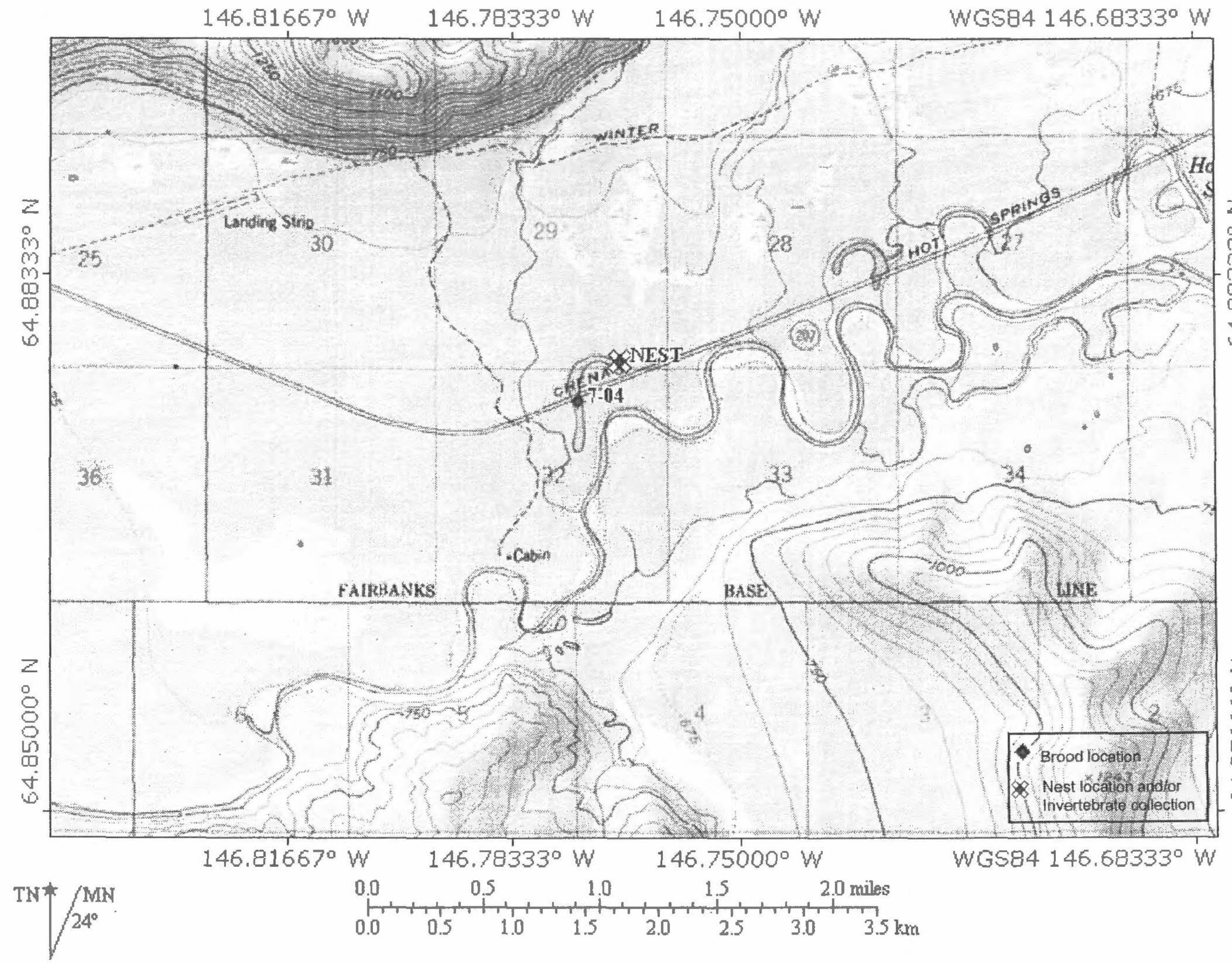


Figure A-40. Locations for brood 106 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

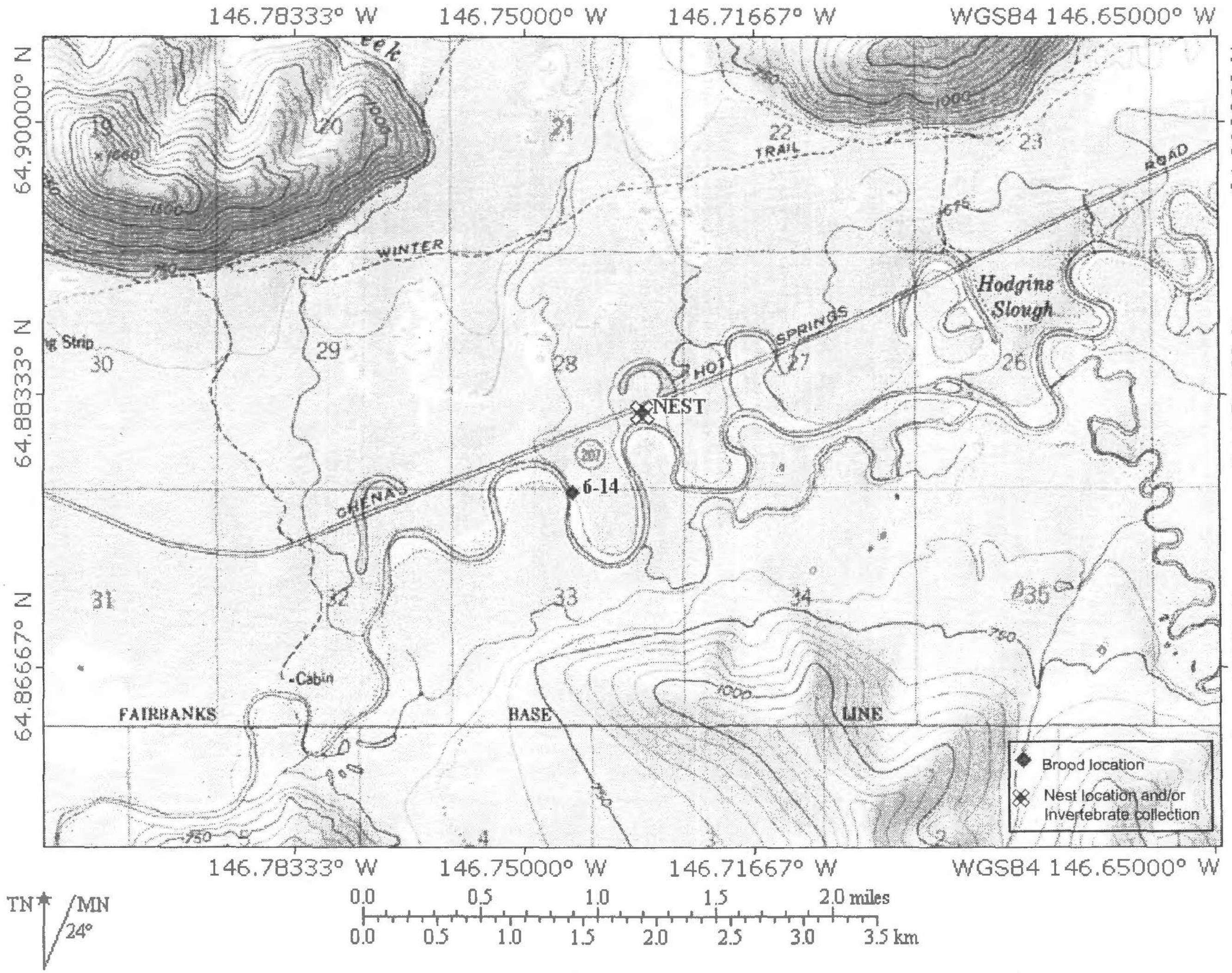


Figure A-41. Locations for brood 107 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

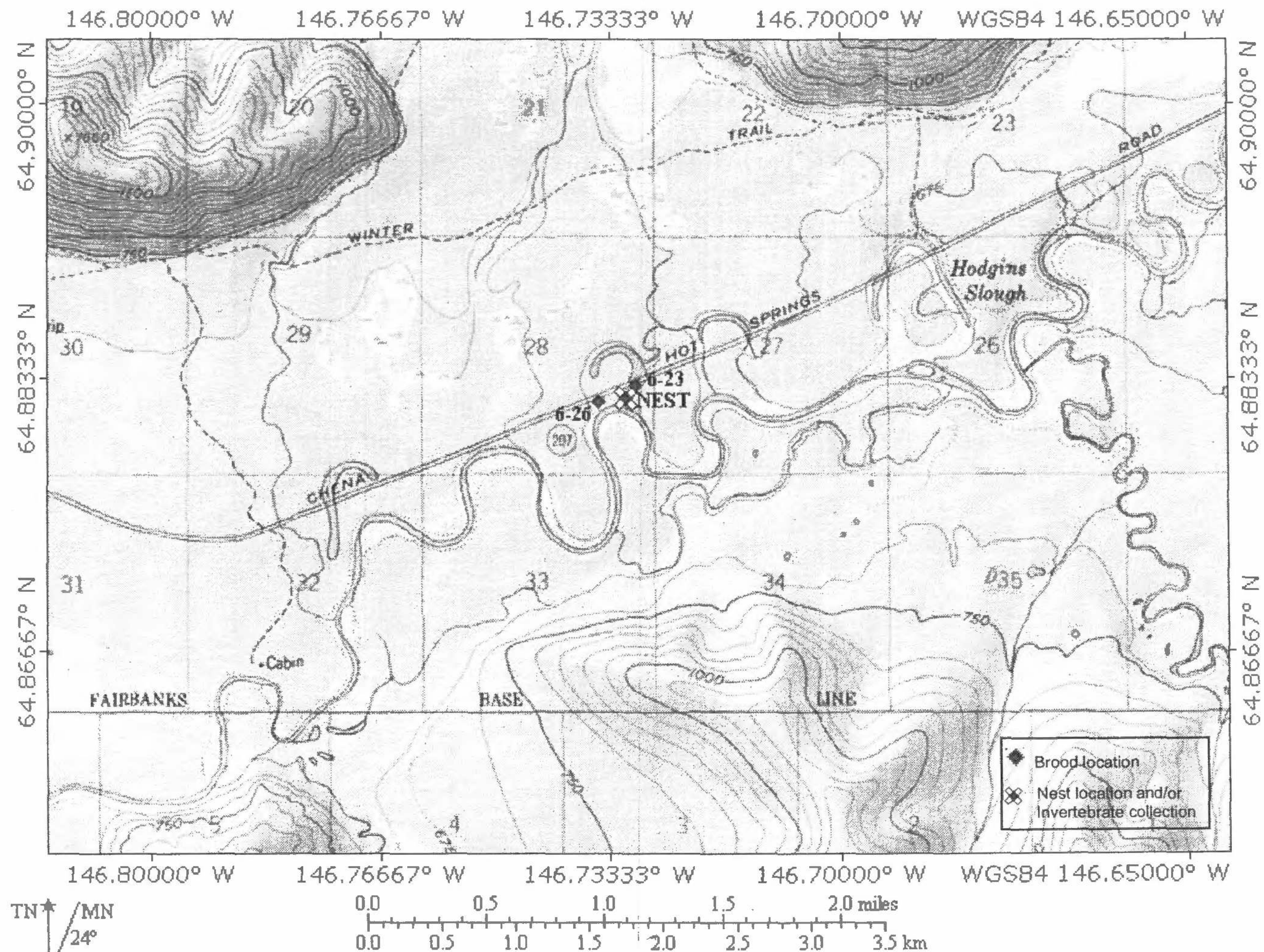


Figure A-42. Locations for brood 108 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

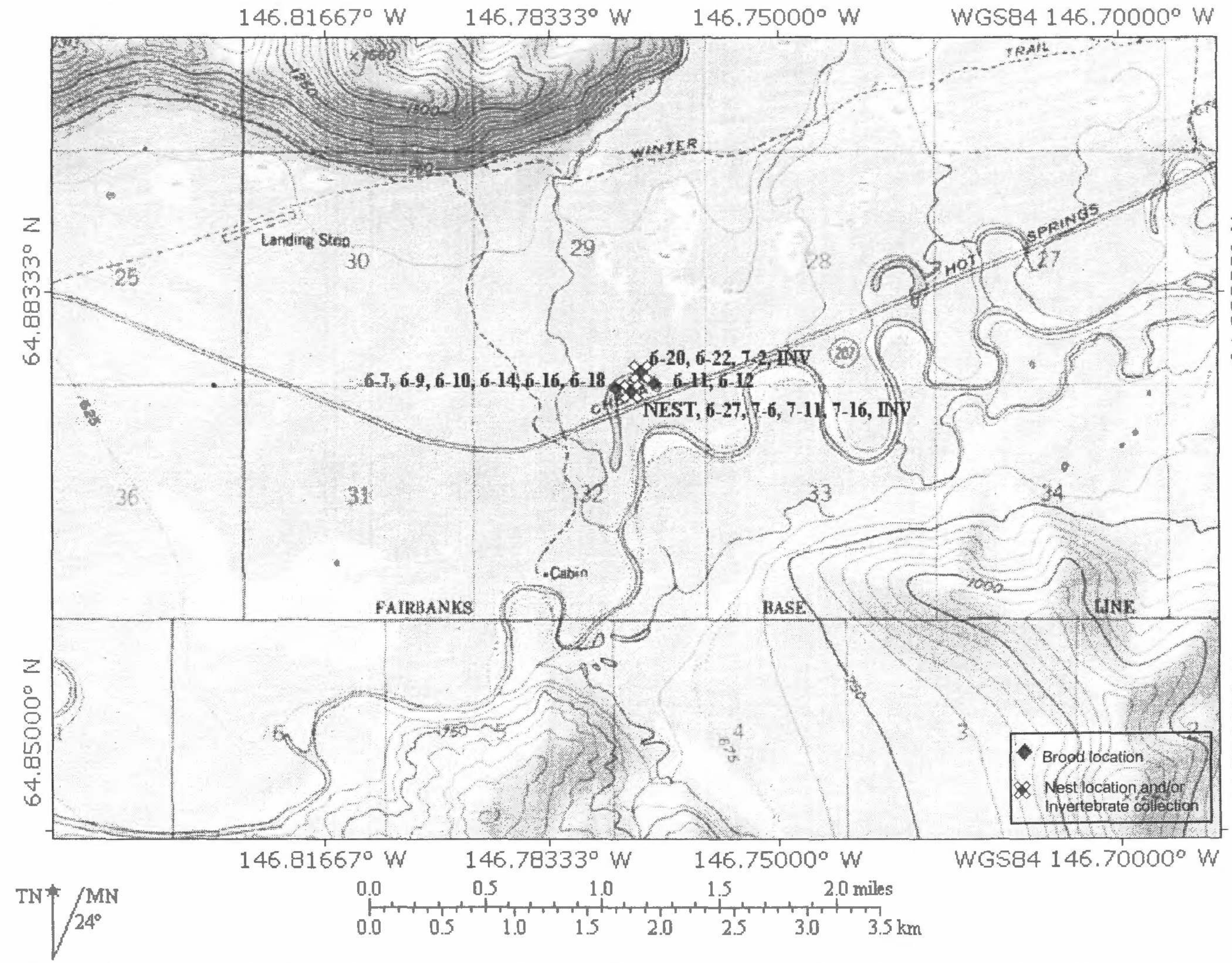


Figure A-43. Locations for brood 111 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

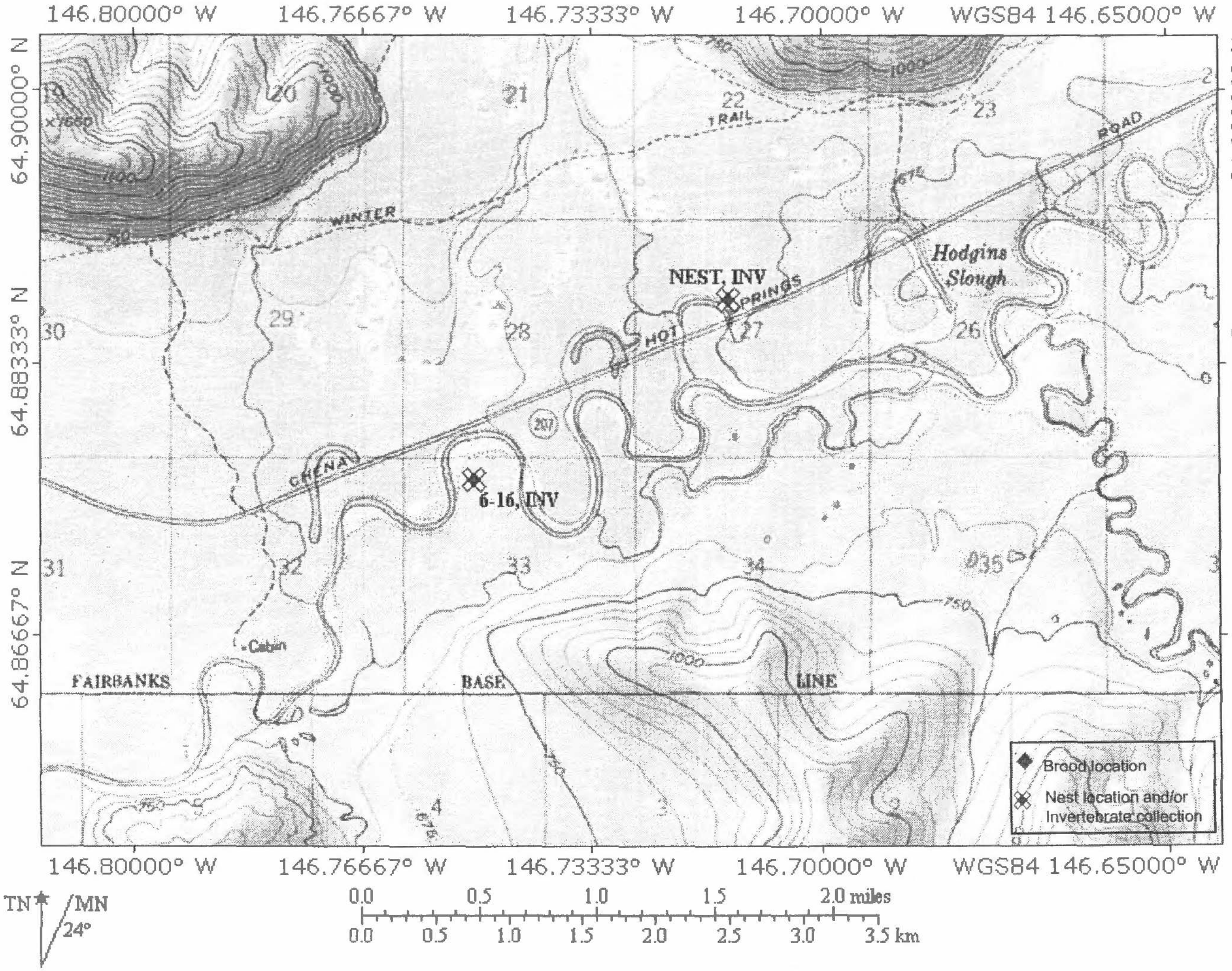


Figure A-44. Locations for brood 114 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

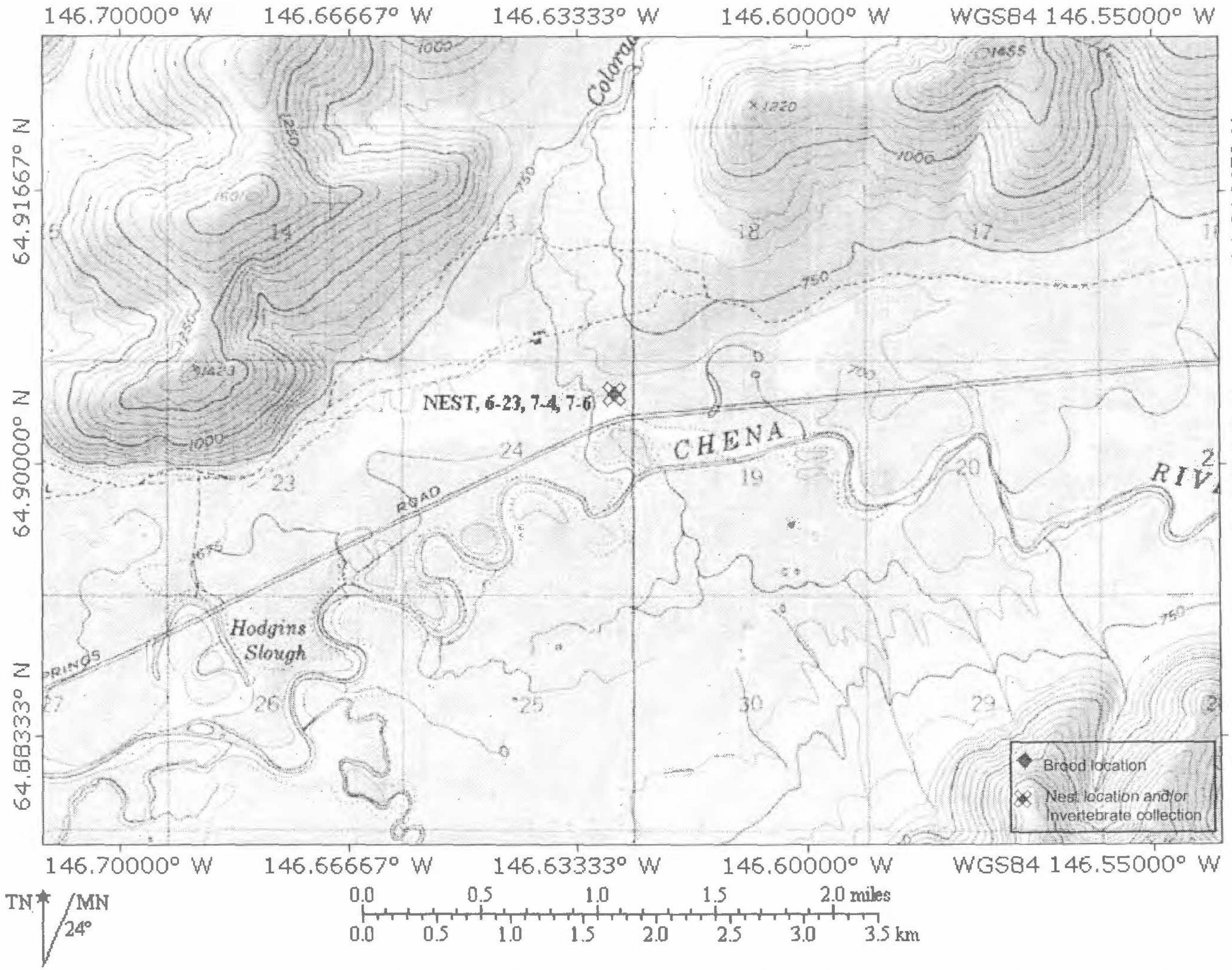


Figure A-45. Locations for brood 120 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

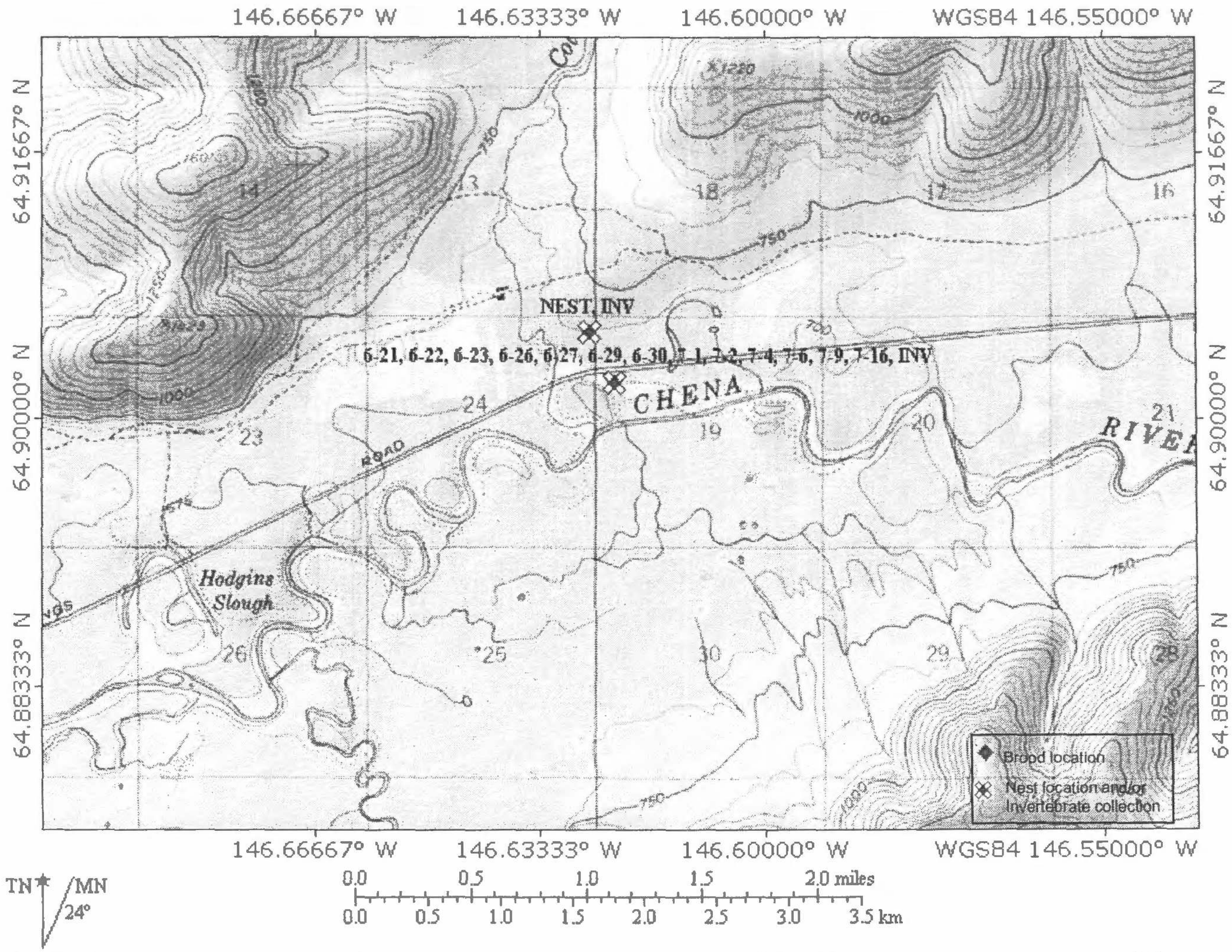


Figure A-46. Locations for brood 121 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

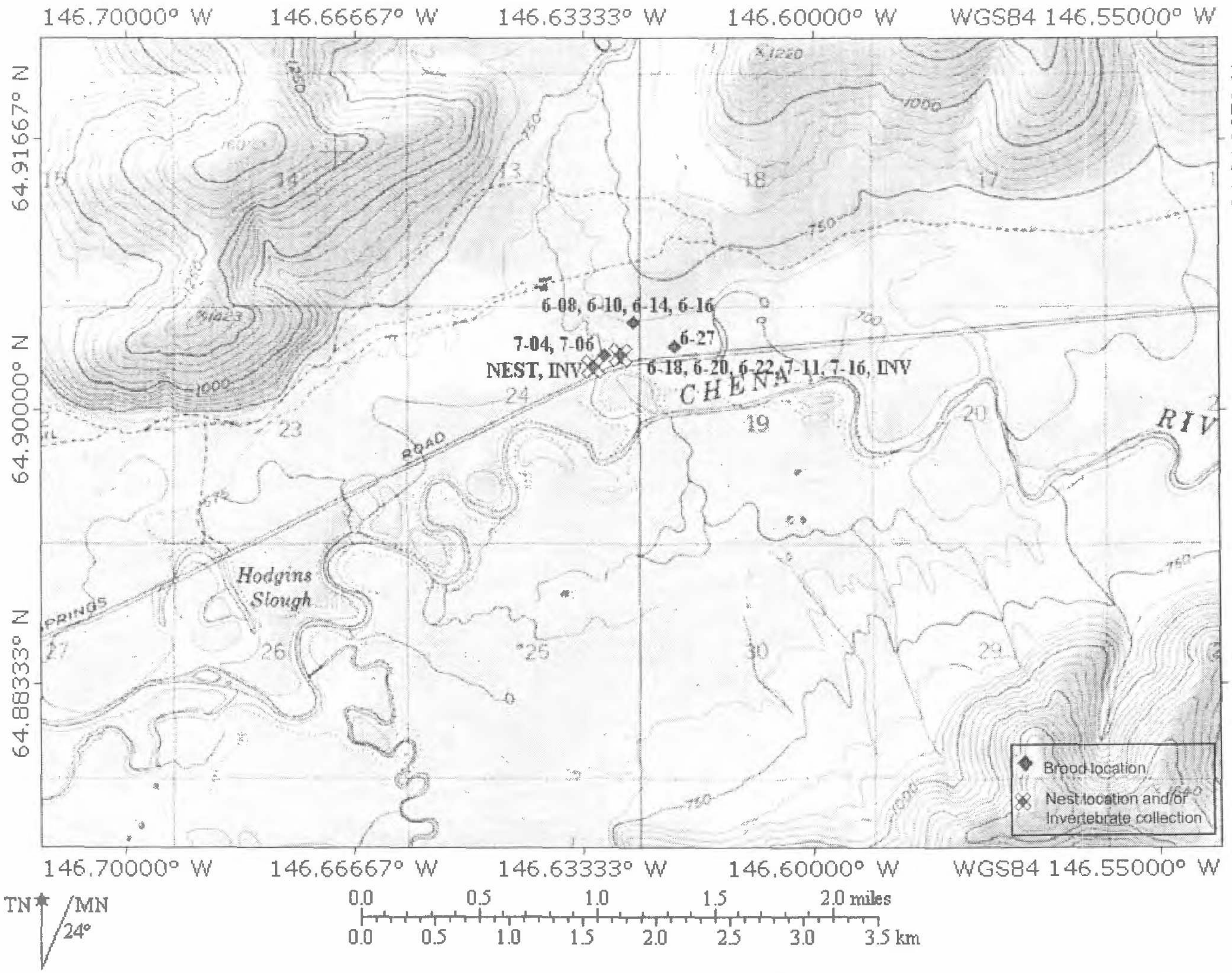


Figure A-47. Locations for brood 125 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

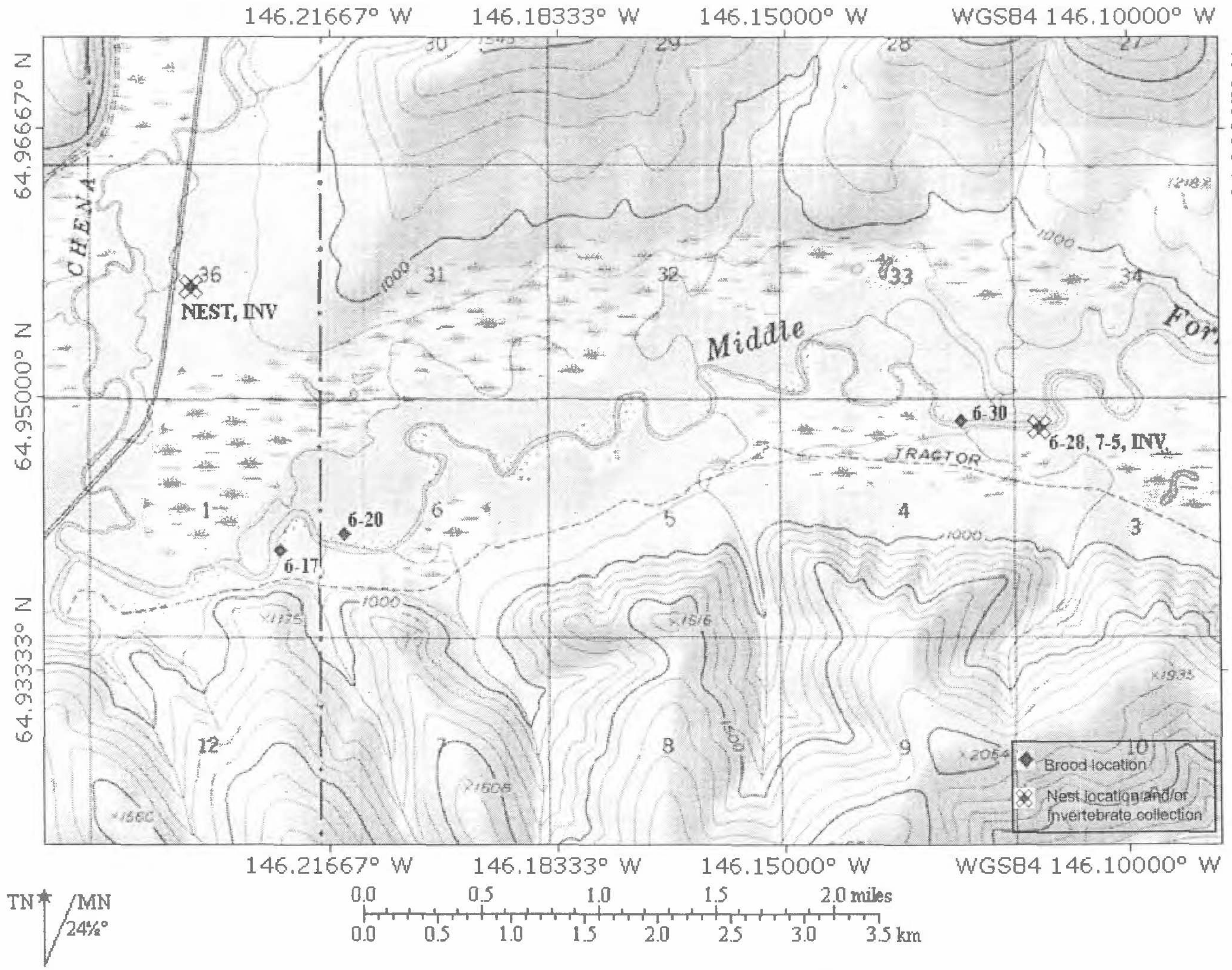


Figure A-48. Locations for brood 130 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

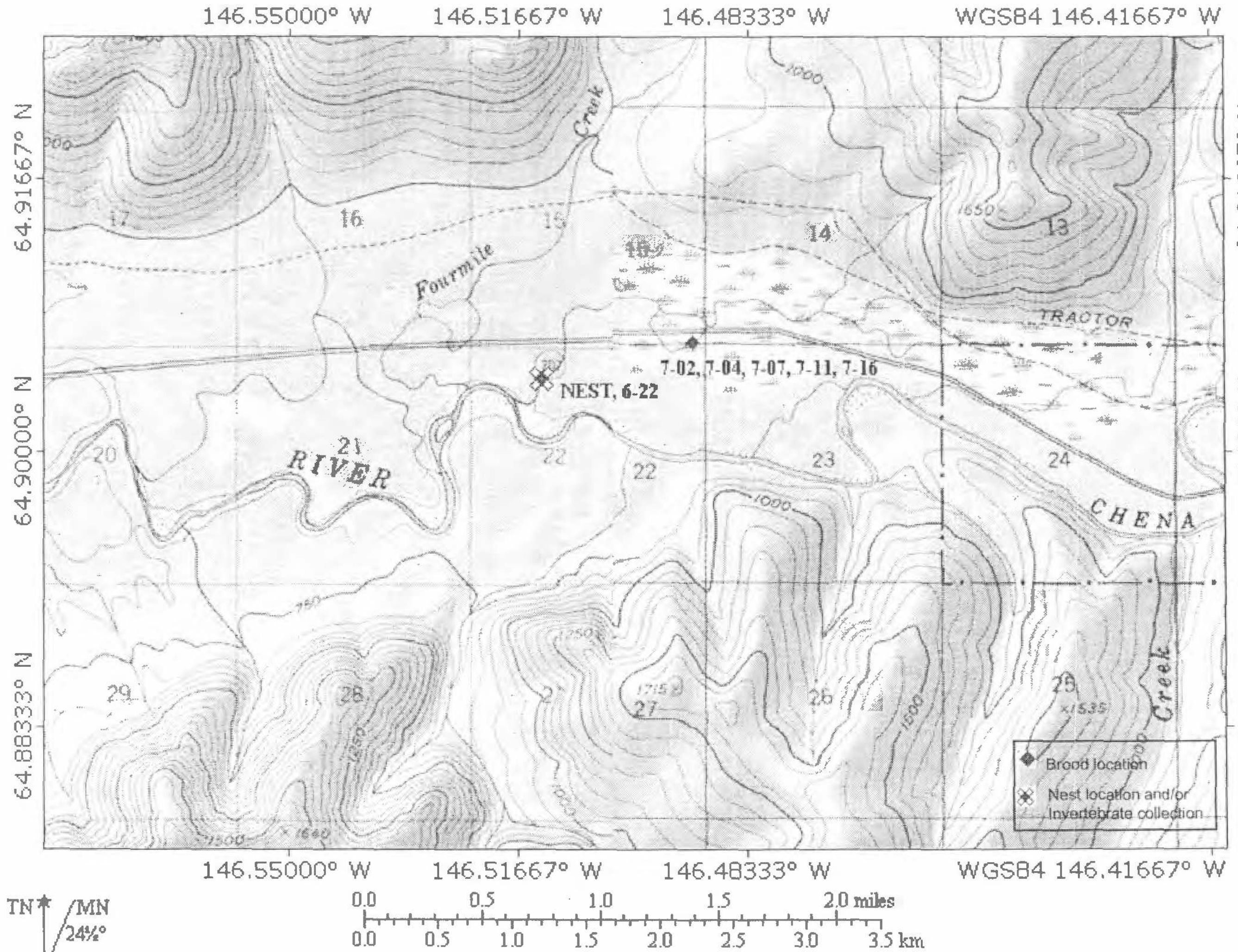


Figure A-49. Locations for brood 132 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

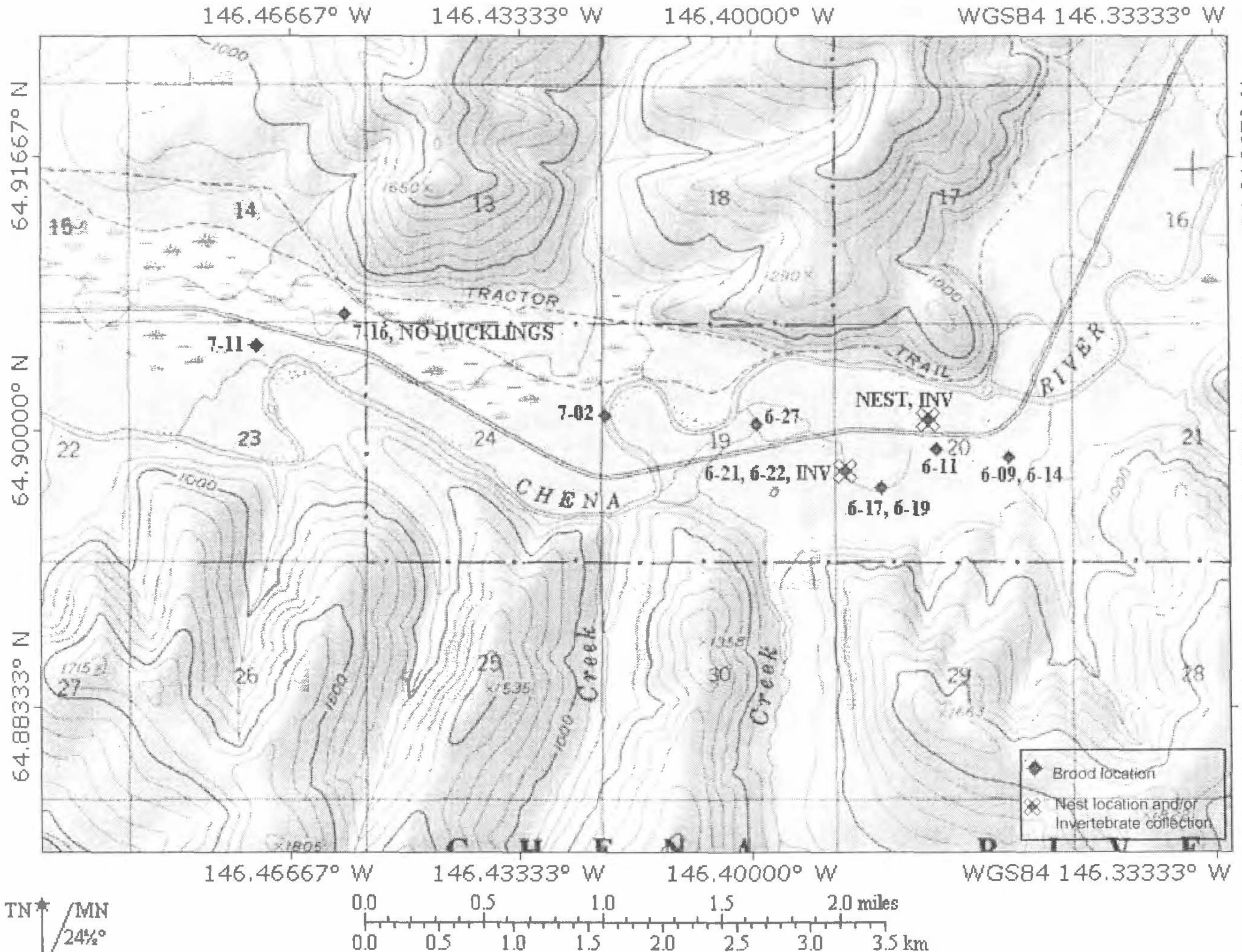


Figure A-50. Locations for brood 138 during the 2003 season. NEST indicates the location of the nest, and the numbers indicate the dates that the brood was relocated at each point. INV indicates locations where invertebrates were collected.

Table A-2. Results of invertebrate collection for brood 2 during 2002. The brood was raised on the nest wetland. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-1.

Taxonomic Group	Number	Size (mm)
Amphipoda	5	2
Amphipoda	1	5
Chironomidae	2	3
Chironomidae	2	4
Chironomidae	2	5
Chironomidae	2	6
Cladocera	106	1
Coenagrionidae	1	10
Dytiscidae (adult)	1	9
Dytiscidae (adult)	1	10
Dytiscidae (adult)	2	11
Dytiscidae (larva)	3	30
Dytiscidae (larva)	1	33
Haliplidae	1	3
Libellulidae	1	20
Planorbidae	1	2
Veliidae	1	1

Table A-3. Results of invertebrate collection for brood 9 during 2002. The brood was raised on the nest wetland. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-2.

Taxonomic Group	Number	Size (mm)
Aeshnidae	1	28
Amphipoda	1	2
Amphipoda	1	3
Amphipoda	8	4
Baetidae	1	3
Baetidae	1	8
Chaoboridae	1	10
Chironomidae	1	4
Cladocera	52	1
Cladocera	15	2
Dytiscidae (adult)	1	11
Dytiscidae (larva)	1	8
Dytiscidae (larva)	2	10
Hirudinea	1	38
Libellulidae	1	12
Libellulidae	1	13
Muscidae	1	3
Planorbidae	1	4

Table A-4. Results of invertebrate collection for the nest wetland of brood 13 during 2002. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-3.

Taxonomic Group	Number	Size (mm)
Amphipoda	1	1
Amphipoda	1	2
Amphipoda	1	3
Amphipoda	8	4
Chironomidae	1	4
Cladocera	107	1
Cladocera	1	3
Cladocera	2	4
Coenagrionidae	1	7
Dytiscidae (adult)	1	12
Dytiscidae (larva)	1	5
Dytiscidae (larva)	1	11
Hirudinea	1	37
Siphlonuridae	1	7
Siphlonuridae	1	10

Table A-5. Results of invertebrate collection for the brood-rearing area of brood 13 during 2002. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-3.

Taxonomic Group	Number	Size (mm)
Amphipoda	1	1
Amphipoda	2	3
Amphipoda	9	4
Baetidae	1	9
Baetidae	1	10
Chironomidae	1	3
Cladocera	34	1
Cladocera	3	2
Copepoda	1	1
Corixidae	1	8
Hirudinea	7	1
Hirudinea	5	2
Hirudinea	1	10
Hirudinea	1	12
Libellulidae	1	14
Planorbidae	1	3
Siphlonuridae	3	8
Siphlonuridae	1	9
Siphlonuridae	3	10
Siphlonuridae	1	12

Table A-6. Results of invertebrate collection for the nest wetland of brood 16 during 2002. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-4.

Taxonomic Group	Number	Size (mm)
Amphipoda	13	3
Amphipoda	31	4
Chironomidae	2	3
Chironomidae	1	4
Chironomidae	1	5
Cladocera	21	1
Cladocera	2	2
Cladocera	4	3
Dytiscidae (adult)	2	10
Siphlonuridae	1	13

Table A-7. Results of invertebrate collection for the brood-rearing area of brood 16 during 2002. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-4.

Taxonomic Group	Number	Size (mm)
Aeshnidae	1	18
Aeshnidae	1	30
Aeshnidae	1	33
Amphipoda	1	3
Amphipoda	1	4
Chironomidae	1	4
Cladocera	234	1
Cladocera	24	2
Cladocera	1	3
Cladocera	3	3
Copepoda	1	1
Dytiscidae (adult)	1	10
Hydracarina	4	1

Table A-8. Results of invertebrate collection for brood 22 during 2002. The brood was raised on the nest wetland. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-5.

Taxonomic Group	Number	Size (mm)
Amphipoda	7	4
Cladocera	190	1
Cladocera	37	2
Copepoda	4	1
Corixidae	2	2
Corixidae	1	4
Dytiscidae (larva)	1	6
Hirudinea	1	9
Hirudinea	1	19
Lymnaeidae	1	8
Planorbidae	11	3
Planorbidae	6	4
Ranidae	1	46

Table A-9. Results of invertebrate collection for the nest wetland of brood 51 during 2002. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-6.

Taxonomic Group	Number	Size (mm)
Amphipoda	1	1
Amphipoda	2	2
Amphipoda	5	3
Amphipoda	7	4
Ceratopogonidae	1	3
Chironomidae	1	1
Chironomidae	2	4
Chironomidae	1	5
Chironomidae	1	6
Cladocera	28	1
Cladocera	3	2
Cladocera	3	3
Copepoda	2	1
Culicidae	1	10
Dytiscidae (larva)	2	5
Dytiscidae (larva)	1	7
Dytiscidae (larva)	1	18
Dytiscidae (larva)	1	25
Ephyridae	1	4
Libellulidae	1	10
Libellulidae	1	19
Muscidae	9	1
Muscidae	1	7
Muscidae	1	13
Planorbidae	1	4
Planorbidae	2	5
Sphaeriidae	1	1

Table A-10. Results of invertebrate collection for the brood-rearing area of brood 51 during 2002. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-6.

Taxonomic Group	Number	Size (mm)
Aeshnidae	1	13
Amphipoda	2	2
Amphipoda	2	3
Amphipoda	5	4
Baetidae	1	7
Cladocera	3	1
Cladocera	1	3
Dytiscidae (larva)	2	3
Haliplidae	1	4
Libellulidae	1	17
Planorbidae	1	3
Sphaeriidae	1	2

Table A-11. Results of invertebrate collection for the nest wetland of brood 63 during 2002. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-7.

Taxonomic Group	Number	Size (mm)
Aeshnidae	1	19
Amphipoda	1	3
Cladocera	24	1
Cladocera	3	2
Libellulidae	2	12
Libellulidae	1	13
Libellulidae	1	15
Libellulidae	1	16
Siphlonuridae	1	9
Siphlonuridae	1	11

Table A-12. Results of invertebrate collection for the brood-rearing area of brood 63 during 2002. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-7.

Taxonomic Group	Number	Size (mm)
Amphipoda	1	2
Amphipoda	19	3
Cladocera	27	1
Cladocera	1	2
Cladocera	6	3
Corixidae	1	2
Tipulidae (pupa)	1	3

Table A-13. Results of invertebrate collection for brood 64 during 2002. The brood was reared on the nest wetland. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-8.

Taxonomic Group	Number	Size (mm)
Amphipoda	31	3
Baetidae	1	3
Baetidae	2	5
Baetidae	6	7
Baetidae	4	8
Baetidae	1	9
Baetidae	1	10
Cladocera	87	1
Cladocera	10	2
Coenagrionidae	4	10
Coenagrionidae	2	12
Corixidae	1	9
Dytiscidae (adult)	1	10
Libellulidae	1	10
Lymnaeidae	1	15
Lymnaeidae	1	16
Planorbidae	1	2
Siphlonuridae	1	9

Table A-14. Results of invertebrate collection for the nest wetland of brood 71 during 2002. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-9.

Taxonomic Group	Number	Size (mm)
Amphipoda	1	4
Baetidae	1	8
Cladocera	13	1
Cladocera	1	2
Coenagrionidae	1	10
Dytiscidae (larva)	1	4
Haliplidae	1	4
Libellulidae	1	10
Lymnaeidae	1	15
Planorbidae	1	1
Planorbidae	1	2
Sphaeriidae	1	2
Sphaeriidae	1	4

Table A-15. Results of invertebrate collection for the brood-rearing area of brood 71 during 2002. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-9.

Taxonomic Group	Number	Size (mm)
Amphipoda	1	2
Amphipoda	1	4
Cladocera	2	1
Cladocera	1	2
Copepoda	2	2
Corixidae	4	2
Corixidae	1	4
Dytiscidae (larva)	3	5
Hydracarina	2	1
Limnephilidae	1	9
Planorbidae	1	1

Table A-16. Results of invertebrate collection for the nest wetland of brood 87 during 2002. The brood was reared on the nest wetland. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-10.

Taxonomic Group	Number	Size (mm)
Amphipoda	1	2
Amphipoda	3	3
Baetidae	1	7
Baetidae	1	11
Baetidae	1	12
Chaoboridae	2	7
Chironomidae	2	3
Chironomidae	2	4
Chironomidae	1	5
Cladocera	28	1
Cladocera	4	2
Coenagrionidae	1	12
Dytiscidae (adult)	1	19
Dytiscidae (larva)	1	4
Isopoda	2	5
Muscidae	1	6
Planorbidae	1	3
Siphlonuridae	1	12

Table A-17. Results of invertebrate collection for the brood-rearing area of brood 87 during 2002. The brood was reared on the nest wetland. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-10.

Taxonomic Group	Number	Size (mm)
Aeshnidae	1	30
Amphipoda	2	3
Baetidae	1	10
Cladocera	21	1
Cladocera	16	2
Cladocera	3	4
Corixidae	1	4
Corixidae	1	8
Dytiscidae (larva)	3	6
Dytiscidae (larva)	2	10
Hydracarina	4	1
Isopoda	1	5
Isopoda	1	6
Siphlonuridae	1	11

Table A-18. Results of invertebrate collection for the nest wetland of brood 97 during 2002. The brood was reared on the nest wetland. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-12.

Taxonomic Group	Number	Size (mm)
Aeshnidae	1	10
Aeshnidae	1	24
Amphipoda	3	2
Amphipoda	1	3
Baetidae	1	6
Baetidae	1	8
Baetidae	2	9
Baetidae	1	10
Cladocera	16	1
Cladocera	31	2
Cladocera	4	3
Coenagrionidae	1	6
Copepoda	4	3
Corixidae	1	5
Dytiscidae (adult)	2	9
Dytiscidae (adult)	1	10
Dytiscidae (larva)	1	10
Dytiscidae (larva)	1	11
Dytiscidae (larva)	1	14
Haliplidae	3	5
Isopoda	1	1
Libellulidae	1	12
Libellulidae	1	14
Libellulidae	1	16
Libellulidae	1	21
Planorbidae	1	5

Table A-19. Results of invertebrate collection for the brood-rearing area of brood 97 during 2002. The brood was reared on the nest wetland. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-12.

Taxonomic Group	Number	Size (mm)
Amphipoda	1	1
Amphipoda	2	2
Amphipoda	1	3
Chaoboridae	1	5
Cladocera	22	1
Cladocera	24	2
Copepoda	3	1
Dytiscidae (adult)	2	8
Dytiscidae (larva)	5	5
Dytiscidae (larva)	1	10
Limnephilidae	1	11
Sialidae	1	10

Table A-20. Results of invertebrate collection for the nest wetland of brood 111 during 2002. The brood was reared on the nest wetland. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-13.

Taxonomic Group	Number	Size (mm)
Aeshnidae	1	28
Aeshnidae	1	36
Amphipoda	1	1
Amphipoda	16	3
Amphipodaa	2	4
Baetidae	1	8
Chrysomelidae (adult)	1	10
Cladocera	35	1
Cladocera	1	2
Dytiscidae (adult)	1	9
Libellulidae	1	12
Libellulidae	1	21
Lymnaeidae	1	8
Siphlonuridae	2	15
Siphlonuridae	1	16
Sphaeriidae	1	4

Table A-21. Results of invertebrate collection for the brood-rearing area of brood 111 during 2002. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-13.

Taxonomic Group	Number	Size (mm)
Aeshnidae	1	18
Aeshnidae	1	20
Aeshnidae	1	23
Chaoboridae	1	9
Cladocera	74	1
Cladocera	3	2
Dytiscidae (larva)	1	15
Dytiscidae (larva)	1	18
Hydracarina	1	1
Siphlonuridae	2	12

Table A-22. Results of invertebrate collection for the nest wetland of brood 125 during 2002. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-15.

Taxonomic Group	Number	Size (mm)
Annelida	23	1
Baetidae	1	6
Cladocera	8	1
Cladocera	2	2
Dytiscidae (larva)	1	5
Siphlonuridae	1	13
Siphlonuridae	1	14

Table A-23. Results of invertebrate collection for the brood-rearing area of brood 125 during 2002. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-15.

Taxonomic Group	Number	Size (mm)
Amphipoda	1	1
Amphipoda	2	2
Chaoboridae	1	7
Chaoboridae	1	11
Cladocera	317	1
Cladocera	23	2
Corixidae	5	2
Corixidae	1	3
Dytiscidae (adult)	1	9
Lymnaeidae	1	18
Siphlonuridae	1	18

Table A-24. Results of invertebrate collection for the nest wetland of brood 138 during 2002. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-17.

Taxonomic Group	Number	Size (mm)
Amphipoda	7	1
Amphipoda	4	2
Branchiopoda	1	1
Chaoboridae	1	14
Chironomidae	1	8
Cladocera	544	1
Cladocera	188	2
Cladocera	31	3
Copepoda	2	1
Dytiscidae (larva)	1	2
Dytiscidae (larva)	2	3
Dytiscidae (larva)	1	5
Dytiscidae (larva)	2	6
Dytiscidae (larva)	1	7
Dytiscidae (larva)	1	20
Libellulidae	1	13
Libellulidae	1	14
Libellulidae	2	15
Libellulidae	1	16
Lymnaeidae	1	14
Planorbidae	1	5
Siphlonuridae	1	5

Table A-25. Results of invertebrate collection for the brood-rearing area of brood 138 during 2002. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-17.

Taxonomic Group	Number	Size (mm)
Amphipoda	3	2
Amphipoda	3	3
Baetidae	1	6
Baetidae	1	8
Baetidae	1	9
Cladocera	19	1
Cladocera	4	2
Copepoda	1	1
Copepoda	1	3
Corixidae	2	3
Dytiscidae (adult)	1	3
Isopoda	3	7
Lestidae	1	11
Libellulidae	1	23
Sialidae	1	7
Siphlonuridae	1	14

Table A-26. Results of invertebrate collection for the nest wetland of brood 16 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-21.

Taxonomic Group	Number	Size (mm)
Amphipoda	2	1
Amphipoda	6	2
Cladocera	115	1
Dytiscidae (adult)	1	13
Dytiscidae (larva)	1	20
Haliplidae	1	3
Planorbidae	1	1
Planorbidae	1	4
Planorbidae	1	5

Table A-27. Results of invertebrate collection for the brood-rearing area of brood 16 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-21.

Taxonomic Group	Number	Size (mm)
Amphipoda	12	1
Araneae	1	4
Chironomidae	1	8
Cladocera	185	1
Cladocera	9	2
Copepoda	1	1
Corixidae	1	1
Corixidae	3	2
Corixidae	1	3
Dytiscidae (adult)	1	11
Dytiscidae (larva)	1	4
Dytiscidae (larva)	3	5
Dytiscidae (larva)	1	6
Dytiscidae (larva)	2	7
Dytiscidae (larva)	6	9
Dytiscidae (larva)	1	11
Haliplidae	1	3
Haliplidae (larva)	2	6
Haliplidae (larva)	1	8
Hydrachnellae	1	1
Hydrachnellae	1	2
Lymnaeidae	1	5
Lymnaeidae	1	9
Planorbidae	1	3
Planorbidae	1	4
Planorbidae	1	5
Viviparidae	1	10

Table A-28. Results of invertebrate collection for brood 22 during 2003. Brood-rearing and nest wetlands are the same. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-23.

Taxonomic Group	Number	Size (mm)
Amphipoda	6	2
Baetidae	1	7
Baetidae	1	8
Baetidae	2	10
Baetidae	12	11
Baetidae	1	13
Chironomidae	16	3
Chironomidae	14	4
Chironomidae	17	5
Chironomidae	1	6
Chironomidae	2	9
Chironomidae	1	10
Cladocera	467	1
Cladocera	1	3
Cladocera	1	4
Corixidae	1	3
Corixidae	2	4
Corixidae	2	8
Dytiscidae (larva)	1	8
Dytiscidae (larva)	1	15

Erpobdellidae	1	50
Haliplidae (larva)	1	6
Haliplidae (larva)	1	7
Haliplidae (larva)	1	8
Haliplidae (larva)	1	10
Leptoceridae	1	3
Libellulidae	1	15
Planorbidae	1	1
Planorbidae	9	2
Planorbidae	5	4
Planorbidae	5	5
Planorbidae	3	6
Planorbidae	1	8
Siphlonuridae	1	13
Siphlonuridae	2	20
Viviparidae	1	2
Viviparidae	1	3
Viviparidae	1	14

Table A-29. Results of invertebrate collection for brood 39 during 2003. Brood-rearing and nest wetlands are the same. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-24.

Taxonomic Group	Number	Size (mm)
Amphipoda	15	1
Amphipoda	2	2
Baetidae	2	4
Baetidae	1	6
Baetidae	1	9
Baetidae	1	10
Chironomidae	6	3
Chironomidae	1	4
Chironomidae	5	5
Cladocera	61	1
Cladocera	2	2
Coenagrionidae	1	19
Decapoda	6	1
Dytiscidae (adult)	1	9
Ephydridae	1	3
Ephydridae	1	4
Libellulidae	1	11
Libellulidae	1	15
Libellulidae	1	23
Siphlonuridae	1	15
Siphlonuridae	1	17
Siphlonuridae	1	20
Viviparidae	1	3
Viviparidae	1	14

Table A-30. Results of invertebrate collection for the nest wetland of brood 41 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-25.

Taxonomic Group	Number	Size (mm)
Calicidae (adult)	1	3
Calicidae (pupae)	1	3
Hydrachnellae	6	1
Salmonidae	1	45

Table A-31. Results of invertebrate collection for the brood-rearing area of brood 41 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-25.

Taxonomic Group	Number	Size (mm)
Aeshnidae	1	17
Amphipoda	1	1
Amphipoda	15	2
Baetidae	1	9
Baetidae	1	15
Cladocera	288	1
Cladocera	12	2
Cladocera	1	3
Cladocera	2	4
Corixidae	7	2
Dytiscidae (adult)	1	8
Hydrachnellae	1	1
Hydrachnellae	1	2
Siphlonuridae	1	6
Siphlonuridae (adult)	1	13

Table A-32. Results of invertebrate collection for the nest wetland of brood 51 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-30.

Taxonomic Group	Number	Size (mm)
Amphipoda	4	1
Amphipoda	1	2
Chironomidae	1	3
Chironomidae	1	4
Chironomidae	1	7
Cladocera	96	1
Cladocera	9	2
Decapoda	3	1
Dytiscidae (adult)	1	8
Dytiscidae (adult)	2	10
Dytiscidae (larva)	1	8
Dytiscidae (larva)	1	9
Dytiscidae (larva)	1	10
Dytiscidae (larva)	1	18
Limnephilidae	1	7
Planorbidae	1	4

Table A-33. Results of invertebrate collection for the brood-rearing area of brood 51 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-30.

Taxonomic Group	Number	Size (mm)
Amphipoda	1	1
Baetidae	1	6
Chaoboridae	1	9
Chironomidae	1	3
Cladocera	64	1
Cladocera	4	2
Corixidae	1	1
Cottidae	1	66
Decapoda	1	1
Dytiscidae (adult)	1	10
Dytiscidae (adult)	1	11
Dytiscidae (adult)	1	13
Dytiscidae (larva)	2	5
Dytiscidae (larva)	2	6
Haliplidae (adult)	1	5
Hydrachnellae	24	1
Planorbidae	2	5

Table A-34. Results of invertebrate collection for the nest wetland of brood 53 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-31.

Taxonomic Group	Number	Size (mm)
Aeshnidae	1	40
Aeshnidae	1	44
Amphipoda	1	1
Amphipoda	2	2
Baetidae	1	7
Chironomidae	3	3
Cladocera	31	1
Corixidae	1	4
Dytiscidae (larva)	1	7
Libellulidae	1	17

Table A-35. Results of invertebrate collection for the brood-rearing area of brood 53 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-31.

Taxonomic Group	Number	Size (mm)
Amphipoda	2	2
Baetidae	1	7
Baetidae	3	8
Baetidae	1	9
Baetidae	12	10
Baetidae	2	12
Baetidae	1	13
Caenidae	1	10
Ceratopogonidae	1	4
Ceratopogonidae	1	9
Chironomidae	3	3
Chironomidae	1	4
Chironomidae	2	6
Cladocera	1	1
Coenagrionidae	1	7
Coenagrionidae	1	14
Coenagrionidae	1	15
Coenagrionidae	1	17
Cordulegastridae	1	5
Corixidae	1	2
Dytiscidae (adult)	1	9
Haliplidae (adult)	1	3
Hirudinea	1	25
Hydrachnellae	2	1
Lestidae	1	20
Planorbidae	1	1
Planorbidae	4	2
Planorbidae	5	4
Planorbidae	1	5
Siphlonuridae	1	17

Table A-36. Results of invertebrate collection for brood 56 during 2003. Brood-rearing and nest wetlands were the same. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-32.

Taxonomic Group	Number	Size (mm)
Aeshnidae	1	25
Aeshnidae	1	38
Amphipoda	8	2
Baetidae	1	8
Baetidae	1	9
Chironomidae	4	4
Chironomidae	1	5
Chironomidae	3	5
Chironomidae (pupa)	1	6
Cladocera	17	1
Copepoda	1	1
Decapoda	1	1
Dytiscidae (larva)	1	8
Ephydridae	1	6
Libellulidae	1	18
Siphlonuridae	1	17

Table A-37. Results of invertebrate collection for the nest wetland of brood 72 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-34.

Taxonomic Group	Number	Size (mm)
Amphipoda	2	1
Amphipoda	2	3
Baetidae	3	5
Baetidae	1	6
Baetidae	1	7
Baetidae	1	8
Cladocera	8	1
Corixidae	1	2
Decapoda	2	1
Dytiscidae (adult)	1	9
Dytiscidae (adult)	1	10
Dytiscidae (adult)	1	15
Ephydridae	1	4
Planorbidae	1	2

Table A-38. Results of invertebrate collection for the brood-rearing area of brood 72 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-34.

Taxonomic Group	Number	Size (mm)
Amphipoda	1	1
Baetidae	1	8
Baetidae	1	10
Chironomidae	1	2
Chironomidae	3	3
Chironomidae	1	5
Cladocera	762	1
Cladocera	2	2
Corixidae	1	8
Decapoda	3	1
Dixidae	1	4
Dytiscidae (adult)	2	9
Dytiscidae (larva)	1	25
Dytiscidae (larva)	1	31
Hydrachnellae	4	1
Limnephilidae	1	14
Limnephilidae	1	16
Limnephilidae	1	18
Nemoridae	1	4
Siphlonuridae	1	16
Siphlonuridae	1	20
Viviparidae	1	10

Table A-39. Results of invertebrate collection for the nest wetland of brood 84 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-36.

Taxonomic Group	Number	Size (mm)
Amphipoda	4	2
Baetidae	2	7
Baetidae	1	9
Baetidae	1	14
Chironomidae	1	4
Cladocera	4	1
Corixidae	1	3
Corixidae	1	9
Lymnaeidae	1	13
Planorbidae	2	1
Planorbidae	1	4
Planorbidae	1	5

Table A-40. Results of invertebrate collection for the brood-rearing area of brood 84 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-36.

Taxonomic Group	Number	Size (mm)
Aeshnidae	1	27
Aeshnidae	2	35
Amphipoda	1	2
Chaoboridae	1	5
Chaoboridae	1	6
Chaoboridae	14	7
Chaoboridae	9	8
Chironomidae	2	3
Chironomidae	1	4
Chironomidae	4	5
Chironomidae	1	9
Cladocera	207	1
Corixidae	29	2
Corixidae	33	3
Corixidae	1	5
Cuculidae (pupae)	1	10
Dytiscidae (adult)	29	5
Dytiscidae (adult)	6	10
Dytiscidae (adult)	1	12
Dytiscidae (adult)	1	20
Dytiscidae (larva)	1	4
Dytiscidae (larva)	1	6
Dytiscidae (larva)	1	9
Dytiscidae (larva)	1	10
Dytiscidae (larva)	1	12
Dytiscidae (larva)	2	15

Dytiscidae (larva)	1	17
Dytiscidae (larva)	1	25
Dytiscidae (larva)	1	56
Dytiscidae (larva)	1	60
Hirudinidae (adult)	1	5
Libellulidae	2	13
Libellulidae	1	15
Libellulidae	1	16
Libellulidae	2	17
Libellulidae	4	20
Libellulidae	2	23
Libellulidae	1	25
Libellulidae	3	26
Libellulidae	2	28
Planorbidae	1	3
Ranidae	1	15
Ranidae	1	20
Ranidae	1	27
Scirtidae	11	5
Siphlonuridae	4	13
Siphlonuridae	2	14
Siphlonuridae	8	15
Siphlonuridae	3	16
Siphlonuridae	8	17
Siphlonuridae	8	18
Siphlonuridae	4	19
Siphlonuridae	7	20
Tabanidae (adult)	1	10
Tetrigidae	1	14

Table A-41. Results of invertebrate collection for the nest wetland of brood 96 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-38.

Taxonomic Group	Number	Size (mm)
Amphipoda	6	2
Baetidae	4	6
Baetidae	3	7
Baetidae	4	8
Baetidae	1	10
Cladocera	11	1
Corixidae	2	4
Dytiscidae (adult)	1	8
Dytiscidae (larva)	1	10
Ephydridae	1	3
Planorbidae	1	2
Ranidae	1	22

Table A-42. Results of invertebrate collection for the brood-rearing area of brood 96 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-38.

Taxonomic Group	Number	Size (mm)
Amphipoda	5	1
Chironomidae	2	2
Cladocera	1	1
Dytiscidae (adult)	1	12
Nematoda	279	2
Planorbidae	4	5
Siphlonuridae	1	24

Table A-43. Results of invertebrate collection for the nest wetland of brood 97 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-39.

Taxonomic Group	Number	Size (mm)
Amphipoda	6	2
Baetidae	4	6
Baetidae	3	7
Baetidae	4	8
Baetidae	1	10
Cladocera	11	1
Corixidae	2	4
Dytiscidae (adult)	1	8
Dytiscidae (larva)	1	10
Ephydridae	1	3
Planorbidae	1	2
Ranidae	1	22

Table A-44. Results of invertebrate collection for the brood-rearing area of brood 97 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-39.

Taxonomic Group	Number	Size (mm)
Amphipoda	2	1
Baetidae	2	7
Baetidae	1	10
Baetidae	1	16
Chironomidae	5	4
Cottidae	1	28
Decapoda	3	1
Haliplidae (adult)	8	5
Hydrachnellae	5	1
Limnephilidae	1	19
Planorbidae	1	3
Planorbidae	3	5
Siphlonuridae	4	5
Siphlonuridae	4	7
Siphlonuridae	3	9
Siphlonuridae	4	10
Siphlonuridae	3	12
Siphlonuridae	9	13
Siphlonuridae	5	15
Siphlonuridae	1	18
Viviparidae	1	13

Table A-45. Results of invertebrate collection for the nest wetland of brood 111 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-43.

Taxonomic Group	Number	Size (mm)
Amphipoda	5	1
Amphipoda	21	2
Baetidae	1	3
Baetidae	1	5
Baetidae	1	6
Baetidae	1	7
Baetidae	1	9
Cladocera	288	1
Cladocera	1	2
Corixidae	1	2
Corixidae	1	9
Haliplidae (larva)	1	4
Lestidae	1	30
Siphlonuridae	2	11
Siphlonuridae	1	13
Sphaeriidae	1	4
Viviparidae	1	3

Table A-46. Results of invertebrate collection for the brood-rearing area of brood 111 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-43.

Taxonomic Group	Number	Size (mm)
Aeshnidae	1	29
Aeshnidae	1	32
Aeshnidae	4	37
Amphipoda	1	1
Amphipoda	4	2
Baetidae	4	5
Baetidae	3	7
Chironomidae	24	4
Chironomidae	1	5
Chironomidae	1	7
Cladocera	98	1
Cladocera	1	2
Corixidae	1	3
Corixidae	1	10
Dytiscidae (adult)	3	9
Dytiscidae (adult)	1	10
Dytiscidae (adult)	1	11
Dytiscidae (adult)	1	17
Dytiscidae (adult)	1	22
Dytiscidae (larva)	1	12
Dytiscidae (larva)	1	19
Dytiscidae (larva)	1	49
Ephydridae	1	5
Salpingidae	1	1
Siphlonuridae	1	13
Siphlonuridae	1	16
Viviparidae	1	5

Table A-47. Results of invertebrate collection for the nest wetland of brood 114 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-44.

Taxonomic Group	Number	Size (mm)
Aeshnidae	1	24
Amphipoda	4	1
Amphipoda	3	4
Baetidae	1	6
Chironomidae	2	5
Cladocera	440	1
Cladocera	9	2
Corixidae	1	2
Dytiscidae (adult)	1	12
Hydridae	1	2
Siphlonuridae	1	10

Table A-48. Results of invertebrate collection for the brood-rearing area of brood 114 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-44.

Taxonomic Group	Number	Size (mm)
Amphipoda	7	1
Amphipoda	21	2
Cladocera	255	1
Cladocera	6	2
Corixidae	2	1
Corixidae	1	6
Corixidae	2	7
Corixidae	1	8
Dytiscidae (adult)	3	2
Dytiscidae (adult)	2	4
Dytiscidae (adult)	1	7
Dytiscidae (adult)	1	8
Dytiscidae (adult)	2	10
Dytiscidae (adult)	1	11
Dytiscidae (adult)	1	12
Dytiscidae (larva)	1	27
Libellulidae	1	6
Libellulidae	1	28
Planorbidae	1	2
Siphlonuridae	1	9
Siphlonuridae	1	10
Siphlonuridae	2	12
Siphlonuridae	4	14
Siphlonuridae	3	16
Siphlonuridae	3	18
Sphaeriidae	2	3
Sphaeriidae	1	4

Table A-49. Results of invertebrate collection for the nest wetland of brood 121 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-46.

Taxonomic Group	Number	Size (mm)
Amphipoda	1	1
Amphipoda	9	2
Amphipoda	1	3
Baetidae	1	4
Baetidae	1	6
Baetidae	1	8
Chaoboridae	1	11
Chironomidae	1	4
Cladocera	42	1
Cladocera	4	2
Corixidae	4	2
Decapoda	1	1
Dytiscidae (adult)	1	8
Dytiscidae (larva)	1	4
Dytiscidae (larva)	2	5
Dytiscidae (larva)	1	7
Dytiscidae (larva)	1	8
Dytiscidae (larva)	5	9
Dytiscidae (larva)	1	19
Hydrachnellae	1	1

Table A-50. Results of invertebrate collection for the brood-rearing area of brood 121 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-46.

Taxonomic Group	Number	Size (mm)
Amphipoda	4	2
Chironomidae	2	5
Cladocera	151	1
Cladocera	9	2
Corixidae	4	3
Dytiscidae (larva)	1	7
Dytiscidae (larva)	1	22
Ephydridae	1	5
Hydrachnellae	1	1
Phryganeidae	1	5
Phryganeidae	4	6
Planorbidae	1	2
Planorbidae	3	5

Table A-51. Results of invertebrate collection for the nest wetland of brood 125 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-47.

Taxonomic Group	Number	Size (mm)
Decapoda	2	1
Dytiscidae (adult)	3	8
Hydracarina	2	1
Limnephilidae	1	6
Limnephilidae	1	10
Limnephilidae	1	18
Sculpin spp.	1	62
Sculpin spp.	1	68
Siphlonuridae	1	16

Table A-52. Results of invertebrate collection for the brood-rearing area of brood 125 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-47.

Taxonomic Group	Number	Size (mm)
Amphipoda	1	2
Chaoboridae	1	6
Chaoboridae	1	7
Chaoboridae	8	9
Chaoboridae	6	10
Cladocera	38	1
Corixidae	1	7
Dytiscidae (adult)	11	5
Dytiscidae (adult)	3	8
Dytiscidae (adult)	2	10
Dytiscidae (larva)	1	5
Dytiscidae (larva)	1	6
Dytiscidae (larva)	1	8
Dytiscidae (larva)	1	9
Dytiscidae (larva)	1	14
Dytiscidae (larva)	1	15
Dytiscidae (larva)	1	18
Hydracarina	1	1
Hydracarina	1	2
Hydracarina	1	3
Limnephilidae	1	5
Planorbidae	1	5
Viviparidae	1	10

Table A-53. Results of invertebrate collection for the nest wetland of brood 130 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-48.

Taxonomic Group	Number	Size (mm)
Amphipoda	22	2
Baetidae	2	7
Baetidae	2	10
Chironomidae	2	5
Cladocera	113	1
Cladocera	2	2
Cladocera	4	3
Cladocera	4	4
Corixidae	1	2
Decapoda	4	1
Dytiscidae (larva)	1	6

Table A-54. Results of invertebrate collection for the brood-rearing area of brood 130 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-48.

Taxonomic Group	Number	Size (mm)
Chironomidae	1	3
Cladocera	4	1
Decapoda	1	1
Dytiscidae (adult)	2	10
Dytiscidae (adult)	1	17
Dytiscidae (larva)	1	5
Dytiscidae (larva)	1	6
Dytiscidae (larva)	1	10
Pelecorhynchidae	1	10
Phryganeidae	1	14

Table A-55. Results of invertebrate collection for the nest wetland of brood 138 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-50.

Taxonomic Group	Number	Size (mm)
Amphipoda	1	1
Amphipoda	8	2
Baetidae	1	10
Chironomidae	1	2
Cladocera	496	1
Cladocera	10	2
Corixidae	6	1
Corixidae	1	2
Dytiscidae (larva)	1	4
Siphlonuridae	2	10
Siphlonuridae	2	12
Siphlonuridae	4	13
Siphlonuridae	2	15
Siphlonuridae	3	16
Siphlonuridae	2	17
Siphlonuridae	1	18

Table A-56. Results of invertebrate collection for the brood-rearing area of brood 138 during 2003. Taxonomic group indicates the type of invertebrate, followed by the number of individuals of each size. Collection location is identified in Figure A-50.

Taxonomic Group	Number	Size (mm)
Aeshnidae	1	21
Amphipoda	3	1
Chironomidae	3	4
Cladocera	93	1
Cladocera	3	4
Corixidae	1	1
Hydridae	1	1
Ranidae	1	23
Viviparidae	1	22

APPENDIX B.

Egg laying data were collected for a subset of the nests monitored during incubation. These data are summarized by nest in Table 1 including the dates and times that females were present at the nest, as well as the duration of the visit. The onset of incubation was also determined for these nests and those data are summarized in Table 2.

Table B-1. Summary of nest visits by female Common Goldeneyes during the egg-laying period by nest and date of visit. On and off indicate when the female entered and exited the nest respectively, and duration indicates the total time in hours and minutes that the female remained on the nest during the visit.

Nest ID	Date	On	Off	Duration
19	5/11/2003	19:20	19:56	0:36
19	5/12/2003	4:50	16:20	11:30
28	5/3/2003	19:14	19:52	0:38
28	5/5/2003	18:52	20:04	1:12
28	5/5/2003	21:42	22:12	0:30
28	5/7/2003	18:28	22:48	4:20
31	5/3/2003	13:05	14:23	1:18
31	5/5/2003	5:47	8:57	3:10
31	5/7/2003	23:19	9:47	10:28
31	5/7/2003	12:55	13:35	0:40
31	5/7/2003	21:09	21:49	0:40
31	5/8/2003	19:51	21:41	1:50
31	5/9/2003	4:49	8:05	3:16
31	5/10/2003	5:43	6:47	1:04
31	5/10/2003	12:25	17:53	5:28
31	5/11/2003	6:19	9:35	3:16
31	5/12/2003	3:51	15:01	11:10
41	5/4/2003	21:49	22:25	0:36
41	5/5/2003	4:41	9:35	4:54
41	5/6/2003	17:45	17:57	0:12
41	5/6/2003	19:27	22:01	2:34
41	5/7/2003	7:55	12:41	4:46
41	5/8/2003	5:03	5:23	0:20
41	5/8/2003	14:37	18:51	4:14
41	5/9/2003	6:23	6:33	0:10
41	5/10/2003	5:55	11:33	5:38
41	5/12/2003	21:41	13:59	16:18

41	5/13/2003	23:55	4:43	4:48
45	5/4/2003	22:16	4:58	6:46
45	5/5/2003	6:08	6:50	0:42
45	5/5/2003	14:12	16:42	2:30
45	5/7/2003	4:30	10:36	6:06
45	5/9/2003	19:36	5:08	9:32
45	5/10/2003	3:32	4:00	0:28
45	5/10/2003	10:48	18:34	7:46
84	5/11/2003	4:58	5:18	0:20
84	5/11/2003	6:12	10:40	4:28
91	5/2/2003	21:12	22:00	0:48
91	5/4/2003	8:40	9:30	0:50
91	5/4/2003	15:36	16:50	1:14
91	5/6/2003	6:28	11:34	5:06
91	5/8/2003	20:46	4:08	7:22
91	5/9/2003	9:06	15:30	6:24
91	5/11/2003	18:50	7:24	12:34
112	5/11/2003	4:10	8:20	4:10
112	5/12/2003	13:56	21:44	7:48
112	5/13/2003	14:28	18:08	3:40
139	5/3/2003	22:44	6:46	8:02

Table B-2. Date and time of the initiation of incubation for 11 Common Goldeneye females including the date of hatch or nest fate if unsuccessful.

Nest ID	Date	Time	Hatch/Fate
19	5/13/2003	5:50	6/12/2003
28	5/8/2003	0:52	6/7/2003
31	5/12/2003	22:37	Predated
41	5/13/2003	19:11	6/12/2003
45	5/11/2003	22:24	6/10/2003
84	5/12/2003	18:38	6/11/2003
89	5/15/2003	16:29	6/13/2003
91	5/12/2003	11:20	Failed
112	5/14/2003	4:32	6/13/2003
139	5/4/2003	20:52	6/3/2003
140	5/9/2003	21:29	Predated